Vol. XLIX

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THE SUSPENDED SPAN of the Williamsburg Bridge across the East River at New York city was connected at the center on Feb. 25, and by laying planks the engineers were able to make the crossing from Brooklyn to Manhattan by walking.

THE INCOME ACCOUNT OF AMERICAN RAILWAYS is the subject of a report recently issued by the Interstate Commerce Commission, covering the year ending June 30, 1902. For 680 railways, with 195,385 miles of line, the results of operation may be summarized as follows:

	Total.	Per mile.
Passenger earnings	$472,429,165	$2,418
Freight earnings	1,200,884,603	6,146
Gross earnings	1,711,754,200	8,761
Operating expenses	1,106,137,405	5,661
Net earnings	605,616,795	3,100

The above figures show earnings from operation only. Other earnings, such as investments, etc., bring the net earnings up to $688,331,287. The dividends paid during the year amounted to $150,685,959. The operating expenses represented 64.62% of the gross earnings from operation.

THE LAW CREATING THE RAPID TRANSIT Commission, which is now building the underground rapid transit railway in New York city, is amended by a bill which has been introduced into the New York state legislature by Controller Grout of New York city. The original act provided that the board should consist of the Mayor, the Controller, the President of the Chamber of Commerce, and William Steinway, Seth Low, John Claflin, Alexander E. Orr and John H. Starin. It was a self-perpetuating body. Mr. Grout's bill proposes that the board shall consist of six members who shall be appointed by the Mayor, and shall hold office for six years. It is provided that the present board shall serve until Jan. 1, 1904. Not less than ten days before Jan. 1, 1904, it shall meet and choose two members other than the Mayor and Controller to serve until Jan. 1, 1906, two to serve until Jan. 1, 1908, and two to serve until Jan. 1, 1910. Thereafter in November prior to the expiration of the respective terms of office of the members of the board, it is provided that the Mayor shall appoint their successors to serve for six years. Vacancies are to be filled by appointment by the Mayor for the unexpired term. In the present law there is a provision that any person or corporation that contracts with the city for rapid transit shall be exempt from taxation in respect to his or their interest under the contract. Controller Grout's bill provides that this exemption shall not extend to any contracting person, firm or corporation so contracting subsequent to Jan. 1, 1903. Another provision of the bill would permit of municipal ownership of all roads hereafter constructed under the authority of the board, provided the board should consider such action wise.

THE ELECTRIC DUCTS built into the side walls of the Rapid Transit subway for New York city are not "equipment" according to the decision of the Appellate Division of the Supreme Court handed down on Feb. 21. The contention which led to this decision resulted from a refusal of Controller Grout of New York city to pay John B. McDonald, the contractor for the subway, the sum of $400,000 claimed for the construction of ducts up to the time the bill was rendered. A writ of mandamus was secured by Mr. McDonald to compel payment, but the Supreme Court refused to uphold it for the reasons stated in Engineering News of Oct. 30, 1902. The present decision reverses the first. Justice Hatch writes the opinion of the Court, which in substance says: It cannot be doubted that both statute and contract contemplated that the Rapid Transit Commissioners should exercise extremely broad powers in providing for the construction of the road and in changing details. When the conclusion was reached that electricity was the only practicable power to be used, the idea of using compressed air having been abandoned, they had a right to have the tunnel made to conform to the requirements of electricity. The contractor was bound to obey the orders of the commission. The city, moreover, has the absolute title to the whole structure, and it seems absurd to assert that the contractor could have any ownership in any part of it, whether ducts or ordinary wall. The ducts are, therefore, a part of the work of construction, and for construction the city must pay. It is therefore directed that a writ shall issue, although it is stated that as regards certain relatively small items an alternative, and not a peremptory, writ of mandamus might be necessary.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a derailment near Lenoir City, Tenn., on the Southern Ry., on Feb. 28. The cause of the derailment is stated to have been due to a landslide, which spread the rails and covered the track. The engine with four cars plunged down a steep embankment. Three persons were killed and a number injured.

A COAL DUST EXPLOSION at the Edison cement plant, New Village, N. J., killed six men and burned five, perhaps fatally. A score of others were injured and several buildings were wholly or partly wrecked. The accounts of the accident are rather confusing, but the manner of its occurrence seems to have been as follows: From the coal storage bins conveyors carry coal to a coal-grinding building, where it is finely pulverized for use in the dust-fuel burners of the rotary kilns. Fire started in one of the coal storage bins and the burning coal was carried to the grinding house, where the coal-dust laden atmosphere ignited with explosive force.

BOILER EXPLOSIONS IN GREAT BRITAIN during the year 1902 are summarized in a report of the British Board of Trade. There occurred 68 explosions, of which 48 occurred on land and 20 at sea; in these accidents 30 persons were killed and 55 injured. Nearly one-third of the explosions concerned not the boiler directly, but boiler fittings or steam pipes. Deterioration was responsible for 21 explosions, defective design and excessive pressure for 15, and improper workmanship for 12. Only six are are charged directly to ignorance or neglect of the attendants. The list of exploded boilers includes 12 horizontal tubular, 7 vertical, 4 horizontal flue boilers, 6 locomotive and 2 water-tube boilers.

THE MENAI SUSPENSION BRIDGE, erected over the Menai Straits from Anglesea to the mainland in 1826 by Telford, was damaged by the gale which swept over the English coast on the night of Feb. 26. The Menai Bridge was one of the earliest suspension bridges, and had a main span of 580 ft., carried by linked eye-bar cables. The nature of the accident to the bridge is difficult to arrive at from the meager and confusing press dispatches, but it would appear that the wind stays were broken, leaving the suspended span to swing free in the gale. Traffic was resumed across the bridge after the storm had subsided.

THE TYPHOID EPIDEMIC AT ITHACA, N. Y., still continues. Up to Feb. 27 the deaths attributed to the epidemic numbered about 40, and the number of cases was placed at 500 to 600. The deaths have been about equally divided between Cornell students and citizens of Ithaca. On Feb. 24, President Schurman issued a bulletin regarding the epidemic and its relation to Cornell University, from which the following statements have been taken: Of 2,700 students at Cornell this year at least one-third had returned to their homes, and 75 were then on sick list. While no absolute proof could be produced, investigations made by the city board of health, and by experts employed by the university, indicate that the infection is due to the public water supply, which is drawn from Buttermilk Creek and Six-Mile Creek. Most of the cases took water from Six-Mile Creek. Each drainage is "in practically the same condition," except that there has recently been a camp of some 50 imported workmen engaged in constructing a dam for the Ithaca Water Co. across Six-Mile Creek. The excrement from these men "was deposited on or near the bank of the stream," and the inference is that the infection was from this source. This must remain an inference, only, until it is shown that some one of these men "was inoculated with the typhoid germ." The men are now scattered, so nothing can be proved from them. The university has an independent water supply, and none of the women students in the Sage College dormitory, and no members of the families of professors living on the campus, have had typhoid fever. The university authorities have arranged to supply the students with pure water, free of charge, and have secured pledges from 306 boarding-house keepers to boil water for drinking and culinary purposes. Since President Schurman issued his bulletin the university trustees have offered to loan $150,000 for the construction of a filtration plant, and on March 2 the people, by a vote of 1,335 to 30, voted in favor of municipal water-works. It is only fair to state that the water company claims that proper sanitary precautions were taken at its camp of workmen.

A STONE CORNICE FELL from the new government building at Brunswick, Ga. The original design was for a carved wooden cornice, and the walls are said not to have been strong enough to support the stone cornice that was substituted. A length of cornice of 70 ft., weighing 80 tons and costing $6,000, was thus destroyed, but fortunately without loss of life.

TEMPORARY PILING IN THE EAST RIVER was damaged by tugboats of the New York, New Haven & Hartford R. R. Co. The piles had been driven to facilitate test borings being made by the U. S. Engineering & Contracting Co., which sued for damages. Judge Thomas, of the U. S. District Court, has handed down a decision to the effect that the piles were not in navigable waters, but over a part of the soil, and the defendants are liable for the damages caused.

FIREPROOF WOOD TESTS are not likely to be standardized as was hoped for from the action taken in New York last spring and noted in Engineering News of May 1. As may be remembered, the tests were to be made by a working committee consisting of Prof. Ira H. Woolson of Columbia University, Dr. Chas. F. McKenna and Prof. C. P. Bliss of New York University. The expenses of the tests were to be met jointly by the Building Department and by the several companies engaged in fireproof wood manufacture. The refusal of the Aldermen to approve the proposed expenditure led to the withdrawal of the Building Department, and then one of the fireproofing companies withdrew. The five other companies signed a contract to share the expense of the tests equally; but shortly afterward one of the companies failed and went out of business and the head of another concern left the country and failed to make good his personal promise to pay. Under these circumstances it was deemed fair to the three remaining companies to suspend the tests and these companies, the American, Fireproofine and Standard, have each paid their proportionate share of the expenses incurred up to the time of suspension.

CANADIAN PEAT-FUEL MANUFACTURE is briefly treated in "Consular Reports" for January. It is stated that the Peat Machinery Supply Co., of Toronto, and the Peat Development Syndicate, of Brantford, have each perfected machines that excel those used abroad, so that the maximum cost of manufacturing peat-fuel is $1.50 per ton. Consul Gunsaulus cautions prospective investors against attempting to manufacture peat-fuel until they have examined these Canadian plants. He adds that it will not pay to work a peat bog that cannot be readily drained, and that the peat should be at least 4 ft. thick, extending over at least 100 acres, to pay for installing a plant. The grass peats of Wisconsin are said to contain too much silt, but the moss peats are of superior quality.

AN IRRIGATION EXPERIMENT IN AFRICA is about to be carried out upon a large scale in the Colesberg district by means of private enterprise. About $1,000,000 will be required and that sum will be furnished by the late Cecil Rhodes' estate, Wernher, Beit and Co., and Mr A. Bailey. 140,000 acres fronting upon the Orange will thus be reclaimed and thrown open for settlers, not as a money-making scheme, but to develop the country. All profits over 5% will be devoted to the settlers. The works contemplated will require 2½ years for completion.

THE SOUND MADE BY A MARCONI transmitter is said to be so great that it is necessary to put cotton in the ears as a protection for the ear drums.

THE CONSTRUCTION OF THE CENTERS FOR THE LUXEMBURG ARCH BRIDGE.

In our issue of Feb. 27, 1902, we described the construction and erection of the 277-ft. stone arch bridge at Luxemburg, and gave the general plans of the masonry work and of the wooden center and service viaduct. The problem of designing a stable and economical center on which to construct an arch of this enormous span was an unusual one, and it was solved in an unusual manner. For these reasons we have been at some pains to secure the actual structural details of the centers used both for the main arch and for the shorter side arches. In this task we have been aided by Mr. John N. Bellwald, of St. Louis, Mo., formerly a resident of Luxemburg, who has obtained from Mr. Rodange, Chief Engineer, Department of Public Works of Luxemburg, the photograph of the arch which we reproduce here, and who has furnished us a paper by Mr. Victor Fonck, Engineer of Public Works, which describes briefly the center construction, and from which we have redrawn the illustrations shown here.

It will be recalled that the Luxemburg bridge is composed of two parallel structures with the space between them bridged over by a thin concrete platform, and that each arch ring was built in segments separated by open spaces which were filled only after all other parts of the ring were completed. The reasons for this form of construction were given in the article published in our issue of Feb. 27; its influence upon the design of the center was to make it possible to use a construction much lighter and more flexible than is ordinarily deemed essential for arch centers, and also one which could be used first for one arch ring and then for the other by being transferred entire from its first to its second position. With this explanation we will proceed to consider briefly the construction actually employed, taking up first the center for the main arch, and second those for the side or approach arches.

CENTER FOR 277-FT. ARCH.—Fig. 1 is a view of the Luxemburg Bridge, with the center in place underneath the second half of the structure.

FIG. 1. VIEW OF LUXEMBURG BRIDGE, SHOWING FIRST HALF COMPLETED, WITH CENTER AND SERVICE VIADUCT IN POSITION.

Fig. 2 shows a side elevation, plan and transverse sectional elevation of the center. The sectional elevation, Fig. 2, shows clearly the relative positions of the two parallel arches composing the main span of the bridge. The center, it will be noted, is just wide enough to support one of the arches; to be used for constructing the second arch it had to be moved sidewise some 11.25 m. (36.9 ft.). To permit of this movement of the

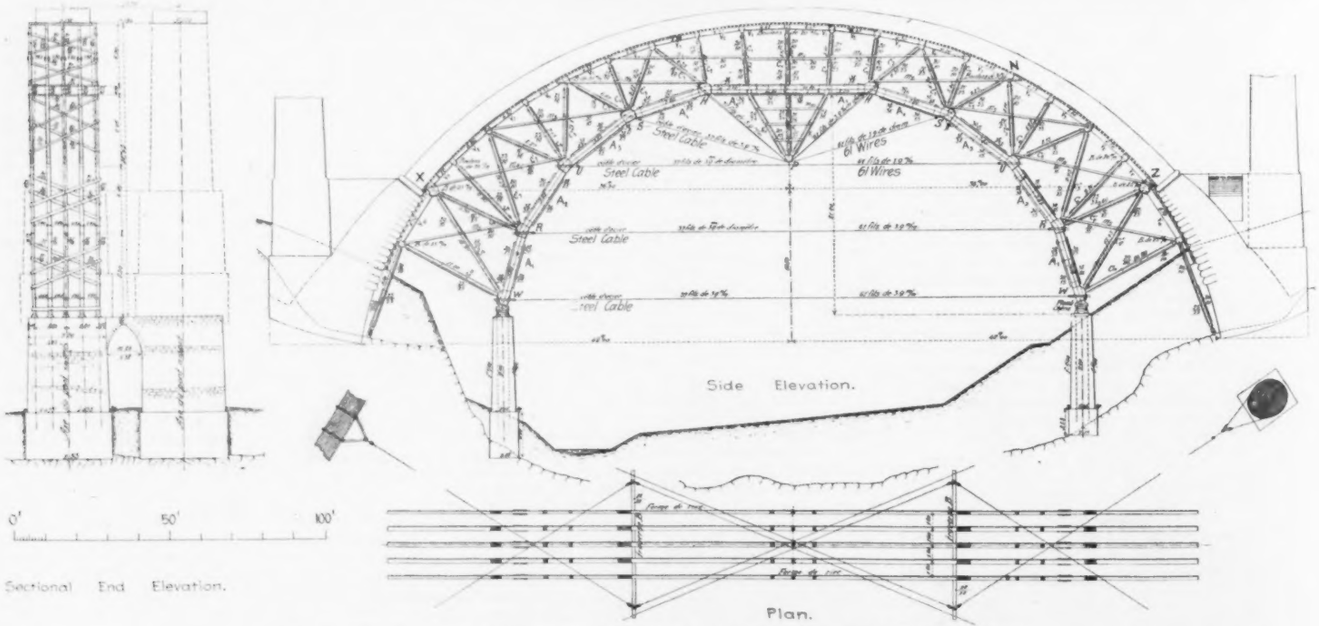
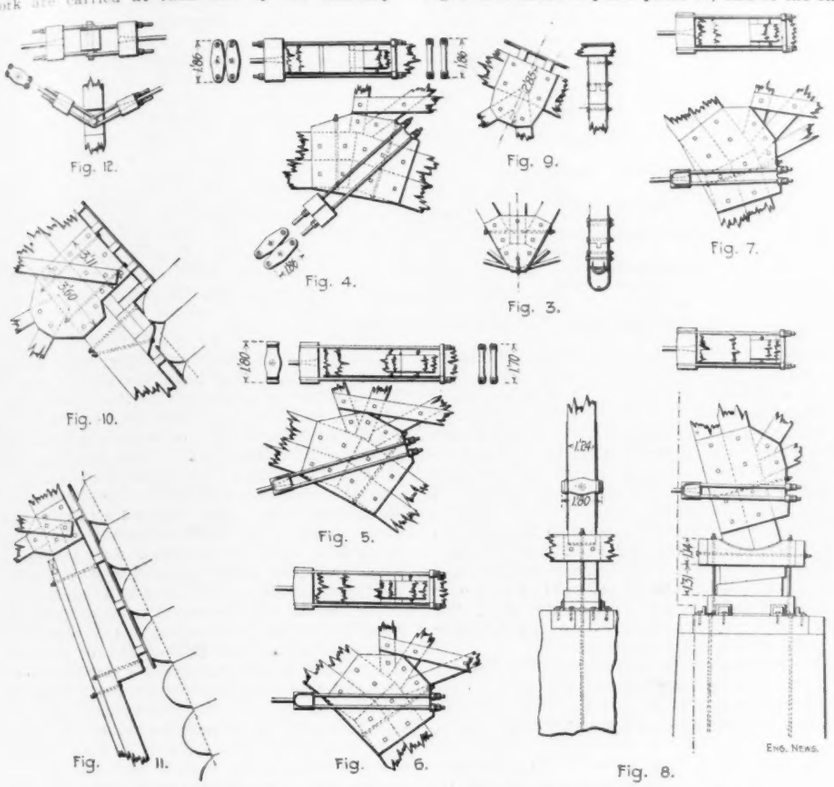


FIG. 2. GENERAL PLAN AND ELEVATIONS OF CENTER FOR 277-FT. ARCH SPAN.

center and also to support it when in use a pair of stone piers connected at their tops by a pointed arch were built on each side of the gorge. The center itself consists of five parallel arch ribs braced together laterally to form a single framework. The intradosal members of this framework are carried at each end by the masonry piers just mentioned; but the extradosal members have independent means of support, as is indicated by the side elevation of Fig. 2. Four wire rope guys anchored in the sides of the gorge hold the framework from tipping laterally.



FIGS. 3 TO 12. STRUCTURAL DETAILS OF CENTER FOR 277-FT. ARCH SPAN.

The construction of all of the arch ribs is similar, but the three interior ribs are somewhat heavier than the two exterior ribs. It will be sufficient, however, to describe the construction of one rib, and in this description we will refer to the ribs shown in the side elevation in Fig. 2. Each rib consists of an intradosal member and an extradosal member joined by a system of struts. The extradosal member is composed of nine panels each consisting of a member composed of two 38 × 38-cm. (14 × 14-in.) timbers fished together in the vertical plane. These panel members butt together end to end, with a zinc plate between the abutting ends and with two steel plates bolted together to clamp the joint laterally. The center, or crown, panel member is trussed, but the others are simple members. Together the nine panel members form a timber arch of polygonal outline, all members of which are in compression. To prevent the deformation of this arch it is tied together by a system of wire rope tie-rods arranged as shown by Fig. 2. Rising from the intradosal member of the rib is a system of struts which carry the extradosal member on which is placed the lagging. It will be noticed that the extradosal member consists of a crown section X Y Z and of two skewback sections. The ends of the crown section are spliced to the skewback section at X and Z, but all the other joints are butt joints. The feet of the skewback sections are supported by screw jacks resting on the ground.

Enlarged drawings of the more important details of the rib construction are given in Figs. 3 to 12. Fig. 3 is a detail of the trussed center panel at the point P. It will be seen that three steel cables pass under the timber struts at this point, two of these join the points H, P, H, and one joins the points S, P, S. Fig 4 is a detail of the panel points H, H, and show clearly the stirrup connection of the cables to the timberwork. Figs. 5, 6 and 7 are details of the panel points S, U and R; it will be noted that the cable connection differs from that at panel points H, H. Fig. 8 is a detail of panel point W, and of the end bracing of the intradosal member on the masonry pier. It will be seen that the panel member has its lower end cut to a cylindrical convex surface, and that this surface rests in a cylindrical concave surface cut out of a timber shoe block. Between the two cylindrical surfaces a plate of lead is inserted. The timber shoe block rests on wedges and is anchored to wooden base blocking which is anchored to the masonry of the pier. Fig. 9 is a detail of the extradosal panel point N; Fig. 10 shows the splice between the crown and skewback sections of the extradosal member of the rib, and Fig. 11 shows the connection between the skewback section of this member and the strut which supports it from the ground.

The arch ribs are braced together principally by X-bracing in the planes of the extradosal member, the web members and the suspended strutting of the crown panel member. As already stated, the center is prevented from tipping sidewise by guy ropes. Figs. 2 and 12 show the manner of connecting these guy ropes to the center. Fir timber was used for all parts of the center, except the wedges and the bearing and base timbers on the masonry piers and some other smaller members which were of oak. The cables and stirrup bolts were of steel, the stirrup yokes were of cast iron, and the joint plates and bolts were of wrought iron. The total amounts of materials composing the center were: for the piers, 365 cu. m. of masonry, 3½ cu. m. of timber and 1,000 kg. of wrought iron, for the centers proper, 339 cu. m. of fir timber and 11 cu. m. of oak timber, and 51,500 kg. of metal.

The framing of the ribs was done on a platform large enough to enable the entire rib to be assembled on its surface. The framed timbers were then erected from the service viaduct. The intradosal members of all five ribs were first erected and braced together by X-bracing. The mode of procedure was to erect the intradosal member of one rib at a time, as follows: The crown panel member was first erected on a platform on the center pier of the service viaduct; the other panel members were then lowered and suspended in position from the service viaduct, and finally the joints were bolted and the tie-rods connected. After all five intradosal members had been completed work was begun at the skewbacks, erecting the web struts and the extradosal panel members and was carried on upward on both sides simultaneously until the crown was closed. To frame the members and transport them to the bottom of the gorge ready to be hoisted into position under the first arch occupied from June 28 to Oct. 22, 1900, and to erect the center complete took from Oct. 22, 1900, to May 1, 1901. In this connection it may be noted that the erection of the service viaduct, containing 60 cu. m. of masonry, 340 cu. m. of timber and 4,000 kg. of iron, exclusive of track rails, took from March 2, 1900, to June 28, 1900. The preparation of the temporary structures ready for commencing the arch ring masonry, therefore, took almost exactly 14 months.

CENTERS FOR APPROACH ARCHES.—The centers required for the approach arches of the Luxemburg bridge were, of course, of insignificant dimensions compared with those of the center for the great main arch, but their dimensions and construction are well worth mention. The side arches are 21.6 m. (70.8 ft.) span and, as in the main arch, their arch rings are built in segments. Fig. 13 shows a side elevation and transverse sectional elevation of the centers employed, and Fig. 14 shows enlarged drawings of several of the more important details. It will be noted that the supports of the center are of the familiar

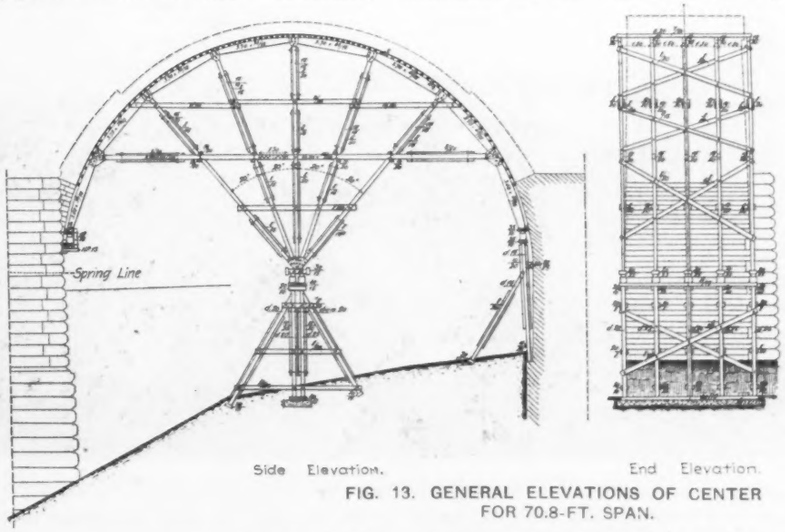


FIG. 13. GENERAL ELEVATIONS OF CENTER FOR 70.8-FT. SPAN.

sand-box type. The other details of construction are shown clearly by the drawings and will not be described further.

SOME NOTES RESPECTING THE LEGAL STATUS OF ELECTRIC INTERURBAN RAILWAYS.

Electric railways of the interurban type, operating at comparatively high speeds on lines of considerable length, are now becoming an important feature in local transportation, and are developing a traffic of their own, independent of their competition with steam railways. Beginning as "street railways" (and often still classed as such), and built originally with little aid from engineers, they have developed into a special class of railway which affords a new and broadening field of engineering work.

A notable feature of some of these electric interurban railways is the fact that the location is governed largely by right-of-way conditions. This has led to the introduction of very sharp curves and a serpentine location to keep within the right of way obtained in advance, and has sometimes led to the use of steeper grades than might otherwise have been adopted in order to keep the width of cuttings and embankments within the limits of the narrow right of way generally obtained for such railways. Both of these peculiarities exist on the lines of the Union Traction Co. of Indiana, described in our issue of Nov. 13 last; and on this system a considerable amount of work is now in progress in improving the location.

In several instances of this kind the location has received sharp criticisms from engineers who have not understood the reasons therefor, and it is not generally recognized that the engineers of electric railways usually work under much closer restrictions that those to which the engineers of steam railways have to conform.

The reason, however, is very simple, and lies in the fact that electric railways built under "street railway" acts, have no power to condemn land for right of way. Consequently, it is not safe to risk arousing suspicion or cupidity by making surveys, and when a general route has been decided upon, the right-of-way agent sets forth to obtain land upon this route. It frequently happens that land cannot be obtained just where desired, and the agent has to shift his line to reach such land as he can purchase. Thus in many cases, where the line would cut across a piece of property, the owner may refuse to sell such a strip of land, but will agree to sell a strip along the boundary, where it will not divide his property. This of course involves an indirect location and probably sharp curves. These particular conditions frequently prevail where (as is so often the case) the electric railway parallels an existing steam railway. The property owner will readily agree to sell a strip of land adjoining that of the steam railway, but will utterly refuse to allow a location that would leave part of his land between the two railways. On the electric railway system of the Union Traction Co. of Indiana, already referred to, it was necessary in three or four cases to purchase tracts of 60 and 80 acres of land in order to get right of way over particular farms. It will be seen, therefore, that the location may be largely determined before the work of the engineer begins.

In view of the somewhat uncertain legal status of the interurban railway, and the special conditions under which such lines must be built and operated, we have deemed it worth while to make particular enquiry as to the points above mentioned, and we present below the information thus obtained in regard to the legal status of electric railways in certain States.

In Indiana, the old laws for street railways would not permit the condemning of land for right-of-way purposes, and thus in the case above noted the large purchases were forced upon the company. The present law does permit street railway companies to condemn land for right of way, but it does not class electric railways with steam railways, nor does it discriminate between suburban and interurban railways. These electric roads are not required to fence their right of way or protect road or railway grade cossings. The line above mentioned was organized as a street railway, with the right to use electricity as a motive power. Some of the other electric roads now being built in Indiana are organized under the steam railway laws of the State, with the right to use either electricity or steam, and these have the same power as steam railways in regard to condemnation of land.

In Illinois, all electric roads which have been incorporated under the general railway laws of the State are classed the same as steam railways, whether built in whole or in part upon private right of way. They have the same rights as steam railways in relation to the condemnation of land, and are under the same regulations in regard to fencing right of way, protecting road crossings by cattleguards, and protecting the railway crossings by interlocking plants.

In the early days of electric railways it was assumed that these railways had a right to cross steam railways at grade wherever they chose, but this is no longer the case. In a case which came up before the Illinois Railroad Commission in 1901, the Chicago, Milwaukee & St. Paul Ry. entered complaint against a grade crossing proposed by an electric railway at Freeport, but the latter denied the jurisdiction of the Commission, on the ground that an electric railway company was not a railway company within the meaning of the statute. The Commission, however, maintained its jurisdiction, supporting its position by precedents, and ordered that the grade crossing should not be built, but that an overhead crossing should be permitted at another point.

The somewhat noted case of the diversion of the Aurora & Geneva Electric Ry. to avoid a grade crossing with the Chicago & Northwestern Ry. at Geneva, Ill., which case involved the status of electric railways in regard to grade crossings, condemnation of land and other matters, was discussed very fully in our issue of May, 18, 1899. In several cases viaducts, bridges and subways have been built by interurban electric lines intended for high speed service in order to avoid the dangers, delays and expenses due to grade crossings and the necessary interlocking plants

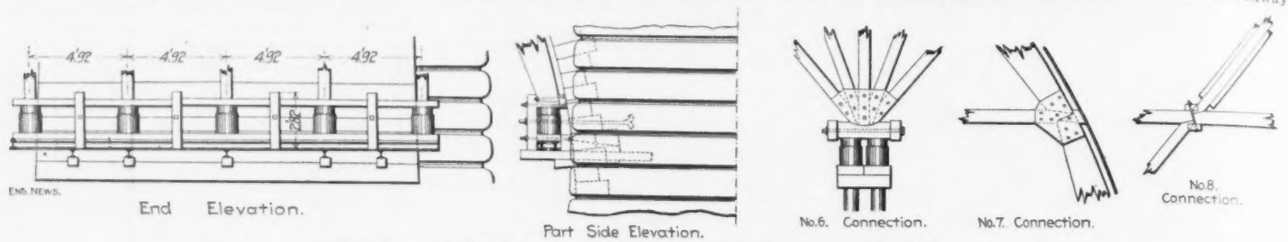


FIG. 14. STRUCTURAL DETAILS OF CENTER FOR 70.8-FT. SPAN.

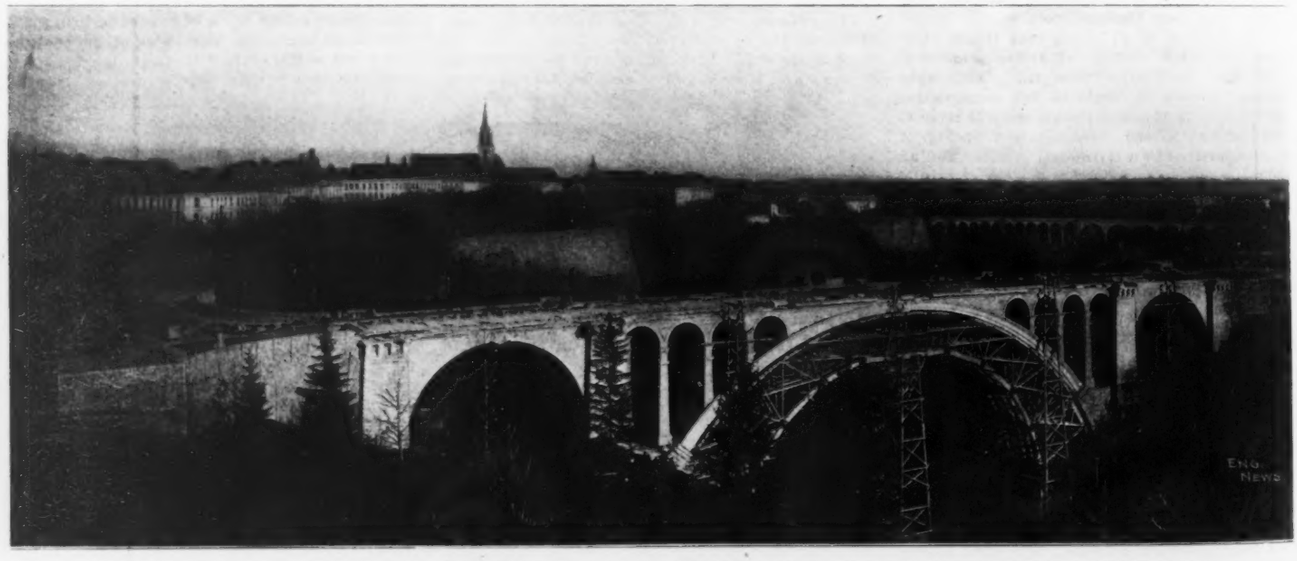


FIG. 15. VIEW OF LUXEMBURG BRIDGE FROM ABOVE, SHOWING PORTION OF THE CITY AND ADJACENT STRUCTURES.

In Ohio, where there has been such a great development of electric interurban railways, these lines are classed as "street railways," depending, however, upon the kind of charter asked for and granted by the Secretary of State. The revised statutes (Section 247) require that they shall protect grade crossings of steam railways by means of interlocking plants or other safety devices to the satisfaction of the Commissioner of Railroads and Telegraphs. By a law passed by the last General Assembly they are authorized to condemn land for right of way. This is not identical with the steam railway law on this point, but answers the same purpose. There has, however, been but little legislation enacted so far affecting this particular class of railways, and the Commissioner does not prepare any statistical matter relative to them. The only authority which the Commissioner has over electrical railways is contained in the above mentioned section of the revised statutes, which relates to the installation of safety appliances at grade crossings with steam railways.

In Michigan, railways of this class do not come within the jurisdiction of the State (as represented by the Commissioner of Railroads), except at their grade crossings of steam railways, but the companies are required to make certain reports (mainly financial) to the Secretary of State. The only control over such railways is vested in the local officers of the cities, villages and townships through which they pass.

In New York, most of the interurban electric railways now built or being projected are incorporated as street surface railways. Under the railway law (Section 90), such companies may condemn land outside of cities, under the general condemnation law of the State. Several interurban railways which were originally operated by steam are now operated by electricity, in a manner similar to street railways. Most of these converted lines run to summer resorts. Several of the interurban electric railways now in operation are laid in great part upon private right of way, and the same arrangement is followed by many others now proposed or under construction. While the routes as proposed in the "articles of association" of the companies are to a considerable extent upon the highways, the tendency is to construct the railways upon private right of way. Under the law, street railways may be constructed in the highways, and while the tendency, as stated above, is to build them on private right of way, much construction will probably be done in the highways, the tracks being generally laid at the side.

When railways of this character are built upon private right of way in New York, the State Board of Railroad Commissioners requires them to be fenced, but has not as yet required the use of cattleguards at road crossings. These railways cannot be constructed across steam railways except in a manner prescribed by the Board, but street surface railways may cross highways at grade, and they usually do so. The general railway law contains an article (No. 4) which applies specifically to street surface railways. Many provisions of the preceding articles of the law have so far been taken also to apply to street railways, although there is some question as to whether most of these preceding articles are not limited in their application to steam railways. For instance, there is now a case before the Court of Appeals, on the question whether a street railway may force a connection with a steam railway under Section 12 of the New York railway law. This section (Section 12, Intersection of Other Railroads) provides that "every railroad corporation whose road is or shall be intersected by any new railroad, shall unite with the corporation owning such new railroad in forming the necessary intersections and connections, and grant the requisite facilities therefor." The Hudson Valley Ry. (a consolidation of several city and interurban electric lines) desires to force a connection with the Boston & Maine R. R. at Mechanicsville, N. Y., but the Appellate Division of the Supreme Court has decided that the above section does not apply to connections of this kind.

In 1901 the Legislature of Connecticut extended the supervision of the Railroad Commissioners over all street railways, requiring that the Commissioners shall inspect these railways every year. No street railway can now be opened for traffic until it has been examined by them. Recommendations made in the report of 1901 are that trolley poles should be at least 5 ft. from the nearest rail where open cars with running boards are operated, and that all large double-truck cars should be equipped with power brakes. The street railway companies also have the right of appeal to the Commissioners on any decision rendered by city or township authorities as to the location or change of location of their lines, and this has already resulted in a number of such appeals.

One rather novel case which was recently decided by the Railroad Commissioners of Connecticut was the right of a street railway company to build an elevated structure in a public street in order to cross over a steam railway. The structure was to be 950 ft. long, and for about 50 ft. at each end would have consisted of masonry walls. The Commissioners held that this would be virtually an elevated railway, that the company's charter gave it no right to build such a railway, and that the abutting owners' rights in the street could not be taken for the purpose proposed. It was further held that as the object of the structure was to avoid a grade crossing with a steam railway, the company should have brought its application under the act (Chapter 166, 1901) by which a street railway having power to lay its tracks on a street which crosses a steam railway at grade, but not having power to lay its tracks over the latter at grade, may petition for the removal of such grade crossing.

A chapter of the railway laws of Connecticut prohibits the construction of an electric (or cable or horse) railway across a steam railway at grade or the construction of a steam railway across the tracks of an electric (or cable or horse) railway at grade. In Connecticut, also, street railways have power to purchase land to enable them to avoid heavy grades or to otherwise improve the line, provided, however, that the company shall not substantially change the course and direction of its road. In Massachusetts they can acquire land for the same purposes.

Although Massachusetts has a somewhat extensive system of electric railways, we are informed by Mr. Wm. A. Crafts, Clerk of the Board of Railroad Commissioners, that there are as yet no long interurban lines built to connect places at considerable distance from each other. All the electric railways in that State, with a few exceptions organized under special acts, are organized under the general law relating to street railways. Several long lines appear on the maps accompanying the Board's report for 1901, but these are made up by the consolidation of connecting roads. There have been only two or three electric railways organized to build lines connecting distant points. One of these is to connect Boston and Worcester, but it is subject to all street railway laws, and is built on public highways and not on private land, except in certain cases. In fact, a street railway company cannot enter upon private land to construct any part of its road except for the purpose of avoiding objectionable grades or curves in the highway. These are, of course, but a small portion of the railway. Such land is acquired by lease or purchase only. In a few exceptional cases where electric railways have been authorized to take land, it has been by special act of the Legislature, and is also usually subject to the supervision of the Board of Railroad Commissioners.

It will be seen that in Massachusetts electric railways are practically confined to the highways, the intention being evidently to make them serve the population tributary to the highways, and not to allow them to freely operate in competition with steam railways. In that State the railways are classed as "railroads" (or steam railways) and "street railways" (the latter being universally electric lines), and for each of these classes there is a code of laws, a large proportion of which are administered by the Board of Railroad Commissioners. Electric railway companies cannot build, extend or consolidate their lines, cross railways at grade, or increase their stock and bond issues without the authority of the Board. They are also required to make annual statistical reports to the Board, which publishes a summary of them in its annual report. The grade crossings of electric railways with steam railways, either in or outside of public highways, as in the cases noted above, are under the regulation of the Board, both in relation to their construction and operation.

It may be of interest to note here that the annual reports of the railway commissioners of New York, Connecticut and Massachusetts show the electric interurban lines. In the New York report they are shown rather indistinctly on the general railway map, and can only be distinguished by careful search. In the Massachusetts report, however, a special map shows these railways in red; the Connecticut report also has a special map in which the single and double track electric roads are indicated by different colors.

THE 20-IN. HYDRAULIC DREDGE "KING EDWARD."*

By A. W. Robinson, M. Can. Soc. C. E.

This dredge is one of the more recent acquisitions of the Department of Public Works of Canada to its fleet of dredges, and is intended for work on the Pacific Coast. The plant of the department in that district up to the present has been small, comprising the dipper dredge "Mud Lark," clam-shell dredge "Muskrat," snagboat "Samson," and some other small plant, the whole under the jurisdiction of G. A. Keefer, M. Can. Soc. C. E., resident engineer. The works in contemplation include principally the rectification of the Fraser River in its lower part, and also such incidental dredging at various points as may be required. It was decided to adopt a hydraulic dredge as being best suited to the conditions.

This type of dredge is sometimes termed a suction dredge, but the writer has adopted the term hydraulic dredge as being more suitable, for the reason that the suction principle is not employed at all for purposes of dredging. The dredge consists essentially of a mechanical excavator, by means of which the material is dug up or loosened and fed into the mouth of the suction pipe and the remainder of the process is simply one of transportation. A centrifugal pump is employed to create a rapid flow through the pipe from the point of excavation to the point of discharge and the solid matter is carried along with the water. In view of the fact that the percentage of solid matter is small and the volume of the water transported is large, it might be supposed that this method of dredging would be a very wasteful one, but there are several other incidental advantages gained at the same time and in the light of practical results the process is not so wasteful as it seems. In the first place, the essential feature of this type of dredge is the disposition of the material, and, therefore, in comparing the results of its work with any other type, the cost of disposing of the material as well as dredging it must be included. It is also especially adapted for filling up and reclaiming low lands, and, in work of this kind, the presence of a large volume of water with the discharged material is a great advantage, as it serves to distribute it over a large area while the water is flowing off.

The velocity of flow in the discharge pipe of dredges of this type varies from 8 to 16 ft. per second, and different kinds of material require different velocities of flow for the most efficient work. Material like clay or soft mud can be transported at a slower velocity than sand or gravel material, which tends to quickly precipitate. A high velocity of flow means a greater friction in the pipe and pump, and, consequently, greater expenditure of power. It must always be borne in mind that a fluid mixture of sand or mud and water is heavier than water alone, and therefore takes more power to pump it against a given head, and, also, the friction in the pipe is greater.

In the earlier hydraulic dredges great trouble was experienced with the abrasion and wear of the interior of the pump. As the first pumps used were similar to centrifugal pumps for water only, it was not an infrequent occurrence for the pump to be renewed after three or four weeks' work. By successful improvements, however, we have been enabled to increase the durability of the pump so that, under ordinary conditions of service, they can be made to last two or three years, and, in fact, the principal parts of them are now so designed as to last indefinitely with the parts subject to special wear arranged to be renewable. The interior of dredging pumps is now made of cast steel instead of cast iron as formerly. This is not, however, on account of the greater resistance to abrasion of cast steel as compared with cast iron, because practically there is very little difference, but it is due to

*Slightly condensed from a paper read at the Montreal meeting of the Canadian Society of Civil Engineers, Jan. 28, 1903.

the fact that the cast steel piece can be worn very thin before breaking. Sometimes centrifugal pumps for dredging purposes are lined throughout with renewable steel plates. This is an advantage in some cases, but, as a rule, the delay and expense of renewing the linings amounts to more than the occasional renewal of an entire pump shell, as the latter can be put in in less time than linings. Also the bolts or fastenings of the linings tend to produce abrasion and wear at that particular point. Wherever there is a crack or joint in the interior of the pump, it is liable to produce an eddy or change of direction in the flow, and a stream of gritty material acting in this way will soon cut out the fastenings and joints of the linings. A great deal can also be done to reduce the interior wear of the pump by careful design. It is better to allow ample clearance for the flow at all points, especially the periphery of the pump, and this can be so proportioned that the abrasion is comparatively slight and evenly distributed. If experience shows that there is undue wear at one point, it means that there is a stream of gritty material flowing or impinging against the surfaces at that point and at a high velocity. This can be remedied by removing those surfaces further away, thus giving the stream more room at that point. Many pump designers are of opinion that the throat or cut-off of the interior of the pump should be as close as possible to the periphery of the pump runner, in order to prevent any flow past this point. Careful experiments have shown that this makes very little difference, and that for dredging pumps especially it is better to allow great clearance at this point, otherwise it will cause great wear.

Hydraulic dredges may be divided into four leading types: First, the sea-going hopper type; second, the lateral feeding or ship-channel type, with floating discharge pipe; third, the forward feeding or Mississippi type, with floating discharge pipe; fourth the radial feeding, with spud anchorage and floating discharge pipe.

The dredge "King Edward VII.," which forms the subject of this paper, belongs to the fourth class—that is to say, it is anchored by spuds and has a radial feed, the cutter describing an arc of a circle about the spud as a center, and the material is principally deposited on shore or to a distance through the floating discharge pipe.

It will aid in understanding the construction of the dredge and the reasons for adopting this particular construction if we first give some consideration to a statement of the conditions to be fulfilled by this dredge. After an examination of the ground and a consideration of the subject these conditions were defined as follows:

First. The dredge must be capable of dealing with sand and soft material at an ordinary rate of 500 cu. yds. per hour.

Second. It must also be able to dig and discharge hard clay, gravel, shell or difficult material and to pass occasional stones up to 10 ins. diam. without difficulty, and also to encounter snags, roots or logs, and cut them up if necessary.

Third. It must be capable of working at any depth down to 40 ft. and making a cut of any width up to 120 ft.

Fourth. It must be capable of cutting its own flotation through a solid bank.

Fifth. It must be able to work in a current of five miles per hour, in either direction and in ebb or flow of tides.

Sixth. It must be able to discharge its material in three different ways, viz.:

1. Into scows alongside.
2. On shore or over an embankment by means of a suspended side-pipe.
3. To distant points through a pipe up to 3,000 ft.

Seventh. It must be self-propelling at a speed of not less than eight miles per hour, and be seaworthy enough to cross the Gulf of Georgia, or go up or down the coast.

Eighth. It must contain quarters for captain and crew with all supplies, and coal for at least ten days.

To fulfill the above conditions the dredge herein described and illustrated was designed by the writer and built by the Polson Iron Works, of Toronto, Ont., and was completed and went into commission in November, 1901.

Referring to the illustrations, Fig. 1 is a deck plan and longitudinal section of the dredge by which the general arrangement of the machinery, crew's quarters, etc., may be seen. Fig. 2 shows cross-section at the pump. Fig. 3 shows the dredge with cutter raised.

The hull of the dredge is 32 ft. wide, 125 ft. long and 7 ft. 9 ins. deep. It is built square-ended at bow and stern, with corners well rounded and a rake on the under body fore and aft in order to make it fairly easy to propel. By referring to the cross-section it will be seen that the bilges are rounded and that the frame of the vessel is built of steel, while the plank and sheathing are of wood. By this construction great strength is obtained, the steel frames being practically indestructible, while the planking can be renewed at any time when necessary, from injury or decay. This form of construction was also especially suitable for erection on the Pacific coast, as the entire frame of the hull could be fitted and erected at the works, where built, leaving only the planking to be purchased and put on at place of erection. The hull is stiffened by two additional steel trusses extending the entire length. These trusses are 15 ft. deep and serve to strengthen and carry the weight of the upper deckhouses. They also sustain the weight and thrust of the front A frame and furnish the necessary support for the wheel beams at the after end. The hull is further stiffened by four transverse water-tight steel bulkheads.

The engines are of the triple-expansion marine type of 500 HP. The engines and pump as they appear in the engine room are illustrated in Fig. 1. There are no special features about this engine which call for detailed description. It is simply a first-class marine engine without the link motion. The work of driving a centrifugal pump is somewhat analogous to that of driving a screw propeller, and therefore the type of marine engine is well adapted to the purpose. There are, of course, many little practical details concerning the manner of attachment of the pump and providing for the special wear and thrust that occur in the pump that are different from marine practice.

The dredging pump itself is of the centrifugal type, of a pattern which has been arrived at through the correction of defects of earlier designs. The pump has a cast-iron shell with cast-steel runner and blades. The suction and discharge pipes are both 20 ins. diam. The blades of the pump runner are faced with renewable steel blades at points of greatest wear and the pump is so designed that it can be readily taken apart and the pump runner removed without taking down the pump shell or discharge pipe connections. The internal passageways of the pump are of large area, so as to freely pass any stones or solid bodies that may enter through the openings of the suction head without injury or liability to choke it. It will readily be seen that if the passages of the pump were of smaller size than the openings through the cutter head that stones or other obstructions might lodge in the pump, but by the foregoing precaution this liability is obviated.

By referring to the plan it will be seen that the entire suction pipe projects in front of the dredge and swings thereupon, its lateral movement being accomplished by means of a block and tackle on each side, the hauling parts of which are carried to the drums of the auxiliary engines. The suction pipe has a universal movement on the hull so that it can raise and lower as well as swing. This movement is provided for by a section of rubber suction hose where it passes over the deck, the suction pipe being attached by hinges to a revolving base plate on the bow of the dredge.

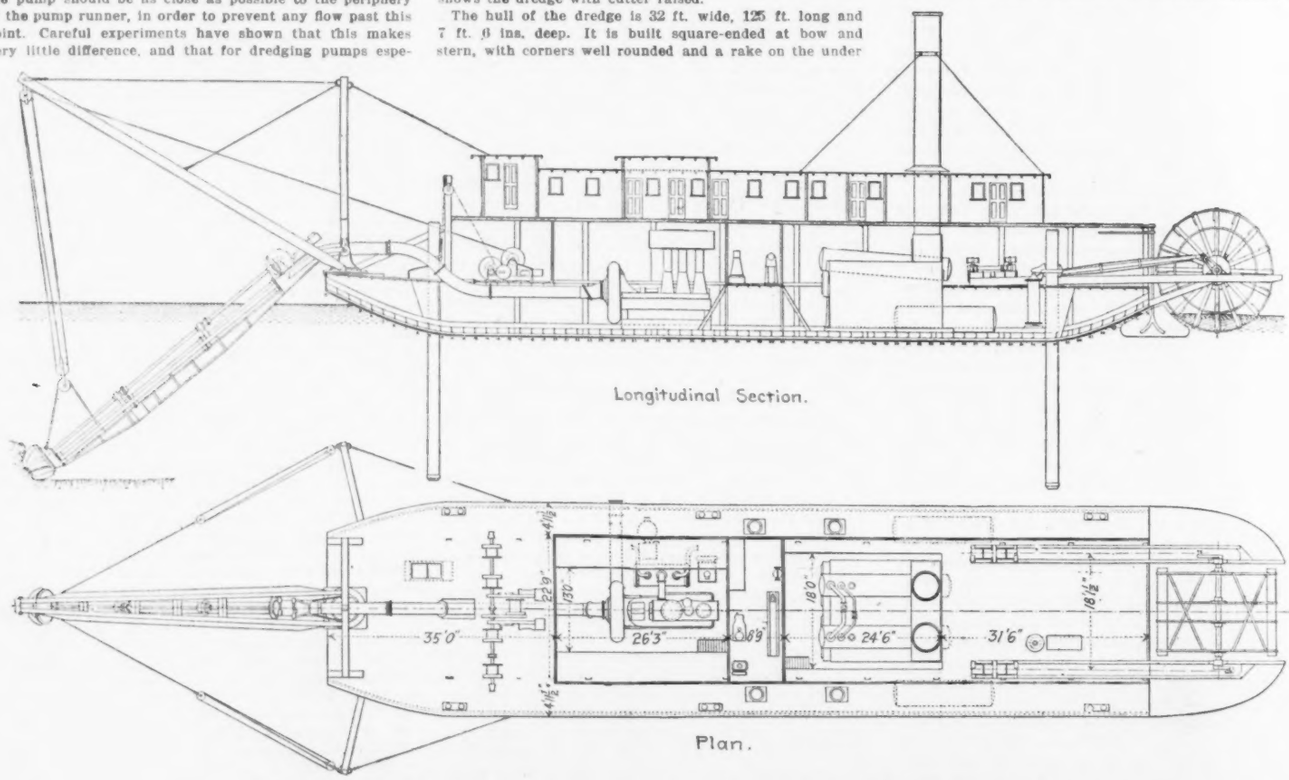


FIG. 1. PLAN AND LONGITUDINAL SECTION OF HYDRAULIC DREDGE, "KING EDWARD."

The material is excavated by means of a rotary cutter head, which is formed of a cast-steel hollow shell and removable cast-steel blades. These blades are arranged on a spiral and so as to give the maximum effect with he least liability of choking. The action of the cutter is such that the blades slice off or excavate the material and feed it into the interior of the shell through the openings, from whence it is removed by the pump suction. The cutter head with its shaft, gearing and all connections are of ample strength to stall the engines which drive them. Thus, in case of an immovable resistance being encountered, nothing worse can happen than the stoppage of the engines, and by slacking off the feed of the cu ter a little, they are enabled to proceed and try again. It is worthy of note that since this dredge has been in commission she has worked in all kinds of material, including roots, stumps, hard-pan and stones, and that no breakage or injury has occurred to the cutter head or its driving gear.

It will be observed that the suction pipe when swinging on the hull will make a cut about equal to the width of the hull, while the latter is anchored by its two spuds. When it is desired to make a wide cut the suction pipe is secured in its mid-position and the swinging lines are carried out on each side to a shore anchorage, and the

entire dredge swings on its stern spud, thus making a cut from 150 to 175 ft. wide at one time. The spuds are oscillating so as to permit the dredge to move up without drifting out of position, and when the move is made, they are lifted and dropped again in vertical position and the work proceeds. The moving up is accomplished by giving a turn or two to the stern wheel by the propelling engines.

The auxiliary engines are on the forward deck. These are for the purpose of working the swinging lines and

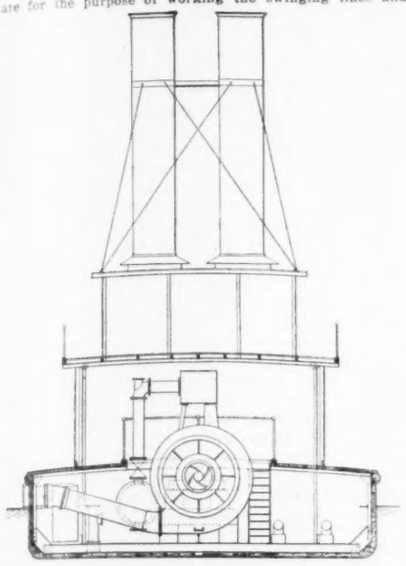


Fig. 2. Cross-Section at Pump of the Dredge, "King Edward."

also hoisting the forward spud. The operator of the dredge controls all the movements of feeding and moving up through the medium of these engines and by bell signals to the engineer. The entire dredge is therefore under the control of one man.

The boilers, as shown on the plan, are of the Heine water-tube type. This type of boiler is not, strictly speaking, a marine boiler, although it has answered very well for this class of work. They are of the usual land type, cased in steel, lined with firebrick. The boilers are designed for a working pressure of 200 lbs. per sq. in., and have an excess of capacity to provide steam for all machinery, and in case of necessity the dredge can work at fair capacity, with only one boiler in commission, while the other is under repairs.

In the engine room the usual auxiliaries are found, such as surface condenser, air pump, centrifugal circulating pump and independent feed and fire pumps. These are all of ample size and conveniently arranged for ease of access and repairs.

The propelling engines are of the stern wheel type, so often seen on the western rivers. They are of the direct-acting long-stroke horizontal type and have cylinders 16 ins. diam. x 6 ft. stroke. They are mounted on a steel frame and have answered the purpose very well.

It will be seen that the whole of the main deck is occupied with machinery and the whole of the upper deck is given up to quarters for the officers and crew.

The performance of the dredge has been quite satisfactory, although no very large or continuous outputs have been made, owing to the fact that the work to be done has been principally small jobs at different points, and in various kinds of material, some of which has been of a very difficult nature. The capacity of 500 cu. yds. per hour has frequently been obtained, and, under favorable conditions, the output, for short periods of time, has approached 1,000 cu. yds., but the average, owing to the reasons already stated, has been much less than this.

To convey the dredged material ashore lengths of sheet steel pipe are used laid on the ground and blocked up where necessary. These pipes are simply slipped into one another like stovepipes, and no special arrangements for keeping them tight. The gravel and clay in the interior soon block up any small openings, and absolute tightness is not required. The material distributes itself over a large area of ground. Thus for land reclamation the value of this type of dredge is evident. The manner of working the dredge and disposing of the material must of course be determined by the local conditions, and while the hydraulic type of dredge has its limitations, its sphere of usefulness, as exemplified in the "King Edward," is considerably widened.

AN EXCEEDINGLY LARGE BOOM DERRICK is being erected at a granite quarry in Barre, Vt. The jib is of Oregon pine 2 ft. 6 ins. in diameter and 93 ft. 3 ins. long. The derrick is designed to lift 100 tons and will be operated by a 100-HP. engine.

NATIONAL CONVENTION ON MUNICIPAL OWNERSHIP AND PUBLIC FRANCHISES.

A convention devoted entirely to municipal ownership and to topics related to municipal franchise companies was held in New York city on Feb. 26, 27 and 28. The meeting was under the auspices of the Committee on City Affairs of the New York Reform Club. The program was arranged by an advisory board of 33 members, comprising business men, city officials, and editors of technical and trade papers, mostly New Yorkers, but also including representatives from Boston, Chicago, St. Louis and elsewhere. Mr. John G. Agar was chairman of the convention, and Mr. John Martin, 50 Pine St., New York city, was its secretary. The papers and proceedings of the convention will be published in full in "Municipal Affairs," a quarterly issued by the Reform Club in the interests of good city government.

RECENT HISTORY OF MUNICIPAL OWNERSHIP IN THE UNITED STATES.

This paper was begun by the late Chas. W. Haskins, and was completed by Dr. E. S. Meade, of the University of Pennsylvania. Save for water-works, municipal ownership has not made much progress in this country, but in that field over half of the total number of plants are owned by cities and towns. In the last ten years 24 states have passed laws permitting some form of municipal ownership. Relief from the excessive charges of private corporations is sometimes needed, as in the case of the Consolidated Gas Co., of New York, which in 1902 paid all charges, an 8% dividend, and put aside a surplus of $2,100,000.

THE POLITICAL INFLUENCE OF CORPORATIONS HOLDING PUBLIC FRANCHISES.

Clinton Rogers Woodruff, of Philadelphia, said that there is one ethical code for business and another for the home, and that the ethical reaction against political corruption due to private corporations is manifesting itself in a demand for municipal ownership.

Mayor Urquehart, of Toronto, said that party politics enter but little into municipal affairs in Toronto. The water-works of Toronto were bought from a private company long ago, and after making large profits above operating and capital charges for three years the rates were cut in half some two years ago. This resulted in a slight deficiency in 1901. In 1902 the city received $235,447 in rentals from the street railway company. The gas rates are only 80 cts. per 1,000 ft., but there is a strong demand for municipal ownership. There is now on foot a promising movement for bringing electric current from Niagara Falls to Toronto and other cities as a coöperative municipal enterprise.

THE CASE AGAINST MUNICIPAL OWNERSHIP IN GREAT BRITAIN.

Mr. Robert B. Porter, an American now residing in Great Britain, sent a paper from that country. He stated that he had been asked to discuss

that boundless field of municipal activity which is prepared to make the British citizen the constant subject of corporation solicitude from the time when in his cradle he is fed on municipal milk to the day when his remains are reduced to ashes in a municipal crematorium.

The rapid increase in local debts in Great Britain, the far lower per capita municipal indebtedness in the United States, the very small profits on the capital invested in revenue-producing municipal undertakings in Great Britain, the failure to provide depreciation funds in the latter country, and the falling price of municipal securities in Glasgow, a town noted for its public enterprises, were all dwelt upon as arguments against municipal ownership.

In the United Kingdom there are 240 municipal and 453 private gas works. The water supply is generally under municipal ownership.

Street railways are about equally divided (as to mileage) in ownership. Two British cities own telephones, or did until Tunbridge Wells "wisely sold its system to the National Telephone Co."

Street railways in Great Britain were retarded by legislation authorizing municipalities to buy out the companies at the end of 21 years, and giving local authorities the right to exclude street railways from their respective districts. The right of purchase, the necessity of a new lease whether or not the purchase was made, and the numerous purchases when concessions expired, kept the companies from adopting electric traction. British cities have themselves been slow in changing from animal to electric traction.

After concluding the review of street railways, Mr. Porter exhibited the bad points in municipal ownership of gas works, electric lighting plants and telephones. Perhaps the strongest point claimed against municipal ownership was that the profits claimed are fictitious; and the next strongest that the army of municipal employees thus created, already some 7,000 in Birmingham and 15,000 in Glasgow, is a menace to good municipal government.

In the concluding portion of the paper Mr. Porter declared that "sound commercial firms in Eng-

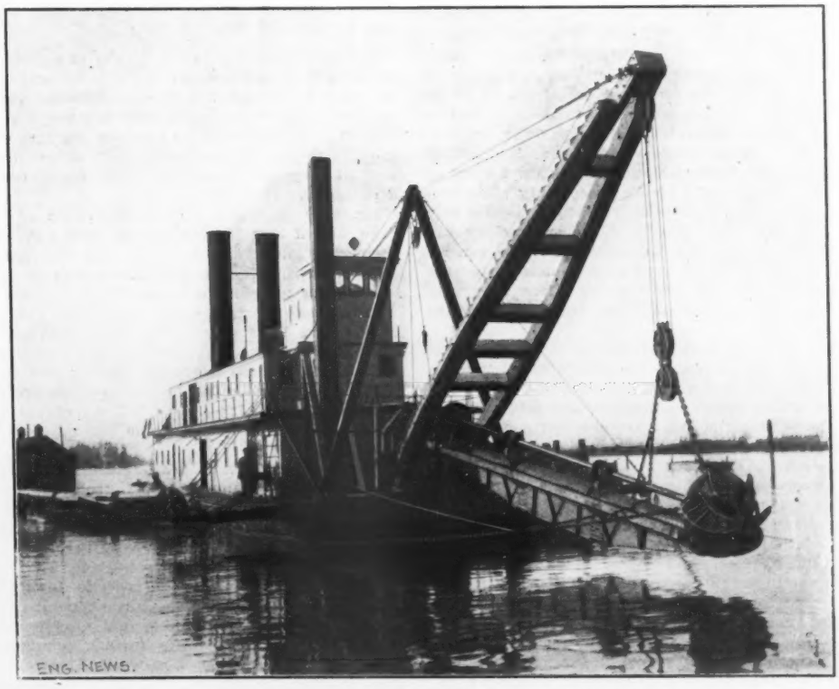


FIG. 3. VIEW OF HYDRAULIC DREDGE, "KING EDWARD," SHOWING CUTTER RAISED.

land pay no more for their capital" than do municipalities; that "it has been demonstrated over and over again that a municipality can do the work no cheaper" than a company; that "there is no proof that the consumer is specially benefited—the service is equally good in the United States under private enterprise, and the cost relative to the cost of labor and raw material, no more;" that the London "Times" asserts that municipal enterprises are "being made the stepping stone to the collective state;" and

gravest uncertainty of all, there is the question whether the purity, such as it is, of municipal government will be maintained if it exercises a multitude of duties, touches finance at many points, and makes politics and business almost synonymous.

THE CASE FOR MUNICIPAL OWNERSHIP IN GREAT BRITAIN.

Mr. Robert Donald, editor of the London "Municipal Journal," sent a paper to the convention in which he said that "the recent attacks on municipal ownership in England have been led or stimulated by people who are directly interested in large combines." The Industrial Freedom League has recently been organized by the "directors of a large electric combine," which frankly acknowledges that the organization was designed "to protect their own and kindred interests." Mr. Porter, the author of the preceding paper, "is among the members of the council of this organization." The League has paid, "at so much per line," for articles against municipal ownership "in provincial journals, and letters inserted in the local press."

Regarding the effect of numerous city employees on municipal government, Mr. Donald stated that many of the employees live outside the town for which they work, that many others are not qualified voters, and "that street railway companies in the past have tried to use far greater influence upon public opinion than ever the employees are likely to do, and have used it solely with the hope of preserving their privileges."

STREET RAILWAYS.

The first of a group of papers on various phases of street railway ownership and control was read by Mr. C. R. Bellamy, General Manager of the Liverpool municipal railways. Liverpool bought out its street railway company in 1897, converted 68 miles to electric traction, added 40 miles of track, cut the fares in half, increased the wages of the men (all of the old employees were taken over), reduced the working day from 13 to 10 hours, and the week from 7 to 6 days, and in 1902 turned $120,000 of street railway revenue into the general treasury, after paying operating expenses, and interest and sinking fund charges. A depreciation fund seems unnecessary when provision is made to redeem the whole capital outlay in 25 years. The men are selected by Mr. Bellamy, with the aid of assistants; the general staff are chosen by means of examinations; the leading engineers are selected after advertisements calling for candidates from all over the country.

Mr. Chas. T. Yerkes, formerly of Chicago, sent a paper from Europe. He considered it "ridiculous to think that a municipality could run a railroad wisely or economically;" and said that the Glasgow municipal railways cost, for construction and operation, sums that "would shame any private corporation."

An address on "City Owning and Leasing" was delivered by Mr. Edward M. Shepard, Counsel to the New York Rapid Transit Commission. He stated that the subway contract which the Vanderbilts, Goulds, and other great capitalists scorned to accept promised so well after it was accepted by Mr. McDonald that when bids were asked on the second, or Brooklyn, contract, the same general interests agreed to execute the work, with the privilege of operating the new route, for one-fifth the cost of construction. In future extensions contractors may even pay for the privilege of constructing roads. The first lease of the right to operate the subway was for 50 years, the second for 35, and probably future leases can be made for 25 or even 20 years.

Mr. Louis D. Brandeis, of Boston, described "Massachusetts' Experience in Street Railways," including revocable franchises, prohibition of watered stock, the franchise tax, and the Boston underground and elevated railways. He evidently thought that Boston handled its subway problem better than did New York, and pointed out how the people insisted upon and secured a short term operating lease. Prof. Frank Parsons said that the revocable franchise was a dead letter, because the corporations have more influence with those who must revoke than do the people.

ELECTRIC LIGHTING.

The opposition to municipal ownership of electric lighting plants was taken by Mr. James Blake Cahoon, Secretary of the National Electric Light Association. The establishment of municipal electric lighting plants is fought by taking the "better element of the city" into one's confidence, showing that element just what lights cost under private ownership, and what figures have been omitted in presenting the cost of lights under municipal ownership; and ending up "with the pretty direct proof that the politicians, who had started the agitation in favor of municipal ownership, would be the men to benefit by the change."

Mr. Cahoon next reviewed the figures relating to the municipal street lighting plant at Chicago, as put forth by ex-Mayor Matthews, of Boston, in 1898, and Haskins & Sells, Expert Accountants, in 1902. According to these figures Chicago would have done better had it continued to take all its lights from private companies, the Haskins & Sells report showing a difference of $49,423 in favor of a private ownership for the years 1887 to 1900, inclusive, and the Matthews' report being even more strongly against the city.

Electric light companies are striving to deliver larger and larger percentages of output to their consumers, and to increase consumption and profits by lowering prices. Under municipal ownership there is taken

away the incentive to progress toward a cheaper method of production and a cheapening of price accordingly, for it is a well-known fact that where municipalities have started any such enterprise, so far as they were concerned, progress has ceased.

If municipal electric light plants would adopt the system of accounting used by members of the National Electric Light Association they could not

furnish light at as low a cost, all things considered, as the city can obtain the same light from the local private company.

The day of secrecy in the matter of accounting by electric light companies has gone by, and there is not a single modern, up-to-date plant in the whole United States which does not stand ready and willing to show to the municipality just what it costs to furnish them with their street lights, and all they ask in addition to the actual cost is a reasonable mercantile profit.

Mr. Edw. B. Ellicott, City Electrician of Chicago, stated that the Haskins & Sells figures of the cost of municipal lighting in that city charged interest on the cities' expenditures, year by year, but omitted to debit the other side of the account with interest on the yearly sums that the city would have had to pay for private lighting. If these charges were made the balance would have been the other way. Moreover, the city now has a lighting plant free of debt. Civil service prevails in the Chicago lighting plant. The hundred men employed have had an average service of seven years.

Mr. A. L. Pierce, of Wallingford, Conn., and Mr. Frederick F. Ingram, of Detroit, recounted in detail the experience of their respective cities with electric lighting plants, which, according to their statements, had been very favorable. A paper by Victor Rosewater, entitled "The Case for Municipal Ownership of Electric Lighting," was read in abstract. The author pointed out that none of the large municipal electric light plants in the United States furnish commercial service. Mr. Joseph E. Lockwood, President of the Michigan Electric Co., of Detroit, presented a detailed analysis, made for Mayor Mabury, of the operations of the Detroit electric lighting plant, which showed a gain of $145,000 for the city, as compared with the acceptance of a bid for a ten-year contract made by a private company in 1893.

GAS WORKS.

A paper against municipal ownership was read by Mr. Allen, formerly secretary of the Massachusetts Gas & Electric Light Commission. He declared that the lowest prices for gas in large cities of Great Britain were where private ownership prevails, and that strikes occur as frequently in public as in private gas works in that country. A paper by Mr. Alton D. Adams, on "Cause and Results of Municipal Gas Plants," was read by title and will appear in the full proceedings of the convention.

Mr. E. W. Bemis, Superintendent of Water-Works at Cleveland, O., stated that the Allegheny municipal electric lighting plant, as compared with the prices paid across the river to the private company in Pittsburg, had saved the city $58,000, and that the city now owns the plant free of debt. Depreciation allowances need not be made where plants are kept in good repair and sinking fund payments are made which will yield the cost of the plant by the expiration of its useful life. On asking the managers of private gas works in Great Britain to name the six best plants to visit in that country each man recommended four municipal and two private works.

Mr. Bellamy, of Liverpool, said the lowest gas rates in England were charged by the municipal plant at Widnes, in Lancashire, where small consumers are supplied at 32 cts., and large ones at 24 cts. per 1,000 cu. ft., and public lamps are free.

In concluding the discussion on gas and electric lighting, Mr. Cahoon said that in all up-to-date private electric light plants depreciation is taken care of. He had just advised clients to refuse to take a $10,000,000 issue of bonds because the company about to issue them had made no allowance for depreciation. A yearly depreciation charge of only 2% would have made a very unfavorable showing for the company.

STATE AND MUNICIPAL OWNERSHIP OF TELEPHONES.

Mr. Union N. Bethell, General Manager of the New York Telephone Co., spoke on "The Superiority of Corporation Ownership of Telephones." It is particularly desirable that the capital invested in telephone systems, even if under public ownership, should yield a reasonable return, since so small a portion of the community uses the telephone.

Mr. Bethell gave a brief but comprehensive review of the telephone systems of Europe, nearly all of which are owned by either the state or the city. This review was accompanied by frequent comparisons between public ownership abroad and private ownership in America, much to the advantage of home conditions. France has had a monopoly of the telephone service since 1889, but on Jan. 1, 1902, there were only 36,000 telephones in Paris, against double the number in New York. The rates in Paris are not low, and the service is technically deficient. Wages of the employees are low. The telephone accounts are not separately kept. In Switzerland there are large annual losses under government ownership. Berlin, under government ownership, has 56,000 telephones, as compared with 96,000 in Manhattan and the Bronx, New York city. Until 1899 there was no night service in Germany. The good municipal service in Stockholm is due to private competition. The ownership of the trunk lines in Great Britain is unsatisfactory. The municipality of Glasgow put in an antiquated call wire system because the subscribers "were used to it." The cost of installation was excessive, and there has been no allowance for depreciation. The dissatisfaction with American telephones is due to misinformation regarding the comparative conditions at home and abroad.

Mr. A. R. Bennett, who has served as engineer for Glasgow and other British municipal telephone systems, sent over a paper on "Municipal Telephony in Great Britain." He said the poor service and high rates of the National Telephone Co. had forced the government to grant licenses for municipal systems. In Glasgow, 3,000 of 5,000 subscribers to the company service joined in a formal complaint, in 1897, against "the badness and dearness of the service." In March, 1901, Glasgow opened a municipal exchange. For the nine months ending May 31, 1902, the city paid operating expenses, interest and sinking fund charges and Post Office royalty, and had a balance of nearly $2,000, after carrying forward some $60,000 of advance rentals. No depreciation was allowed, because the system was entirely new, but one is proposed.

At Tunbridge Wells, before the municipality installed telephones, the company had but 120 subscribers in a population of 90,000, spread over 180 square miles. Over 90% of the subscribers signed a petition to the postmaster-general to the effect that the existing service was unsatisfactory and dear. The municipal system went into operation in 1901 with 300 subscribers, and on Nov. 27, 1902, it had 920 subscribers' lines. The National Telephone Co. cut under the municipal rates, reducing its own former charge of $48 a year to practically $20.

A change in the personnel of the town council in November, after a canvass in which it was falsely claimed that the municipal plant was being operated at a loss, was followed by the sale of the town system to the National Telephone Co. The price was about $135,000, which was nearly $15,000 more than the original cost; and the company agreed to maintain its new schedule of low rates.

Portsmouth began to operate a municipal plant in December, 1902, and Swansea and Brighton each have plants under construction. Hull is advertising for bids, and Manchester, Salford, and Stockport have a joint municipal scheme under way.

Prof. Frank Parsons, of the Boston Law School, presented some "Reasons for Public Ownership of the Telephone." Paris, under public ownership, has 13 telephones per 1,000 inhabitants, and London, under private ownership, but 7. Wages abroad are better under municipal than under private ownership. Under similar conditions, and in the same country, rates are lower under public ownership. Figures in proof of this statement, and of the great reduction in American rates under the competition of independent companies, were given; also many figures designed to show that American rates and profits are excessive.

AN OBJECT LESSON IN THE MUNICIPAL OWNERSHIP OF WATER SUPPLY.

Mr. Wm. R. Hill, M. Am. Soc. C. E., Chief Engineer to the Croton Aqueduct Commission, described at length the municipal water-works, built with Mr. Hill as engineer, which displaced the very inadequate private works in Syracuse. In the first seven years of its operation the income from the Syracuse works paid all operating expenses and interest charges, and $320,000 for construction. The old company received an equivalen of $55 a year for hydrants. This rate was reduced by the city until it was $24 in 1899, and nothing in and since 1900. The city has also relieved new patrons of the expense of the service pipe from the street main to the curb line, and has made sweeping reductions in private water rates. The fire insurance rates in Syracuse have been reduced 25% since the municipal works were built.

Col. Robert G. Monroe, Commissioner of Water Supply, New York city, speaking to the general subject of municipal ownership of water-works, said he thought it was a purely academic question. Thos. Fulton, Secretary of the New York Citizens' Union, favored municipal ownership, with private operation. No company, he claimed, would even have allowed the enormous waste of Croton water that has taken place in New York during the past 65 years.

MUNICIPAL OPERATION NECESSARY TO CO-ORDINATION OF MUNICIPAL SERVICES.

Mr. John De Witt Warner, President of the New York Municipal Art Commission, submittted a long paper, in the course of which he outlined the consolidation of street railway interests in Greater New York, and the affiliation of the underground and elevated railway interests. Among other things, he said:

> In short, it is now clear, not merely that private capital is thoroughly awake to the advantages of combined ownership of various franchises and coördinating varied public services, but that most strenuous and well-planned attempts are now making to secure for a certain financial coterie a public service monopoly here.

PUBLIC SERVICE CORPORATION CONTROL AND TAXATION.

Dr. Charlton T. Lewis, Counsel for the New York Mutual Life Insurance Co., plead for the complete divorce of government and business, urging that inefficient corporation service and high rates therefor could never be secured so long as municipalities themselves had business interests. He recognized no evils of private ownership except poor service and high charges, and favored property qualifications for municipal voters.

Mr. R. R. Bowker, formerly Manager of the Edison Illuminating Co., New York city, believed that there should be the widest possible separation between business and politics. Notwithstanding this, the municipality ought to own everything connected with its street, but public utilities should be leased to operating companies. He believed in the fullest publicity of accounts, the prohibition of over-capitalization, limited earnings, and a thorough system of municipal inspection. In answer to a question as to how competent inspection was to be secured, Mr. Bowker replied, by paying for it, and added that when he was connected with the Edison Co. his salary was higher than that of the mayor of New York city.

Mr. Heineman, of Detroit, said that the people of that city do not distrust human nature as does Dr. Lewis. It was not 19 men out of 20 that they feared, but the twentieth man, working in the interest of private corporations.

A paper by Mr. Allen Ripley Foote, read in abstract, argued that municipally and privately owned utilities should be put upon an identical footing as regards taxes, insurance, depreciation, right to use the streets, and a rigid system of uniform public accounting. Capital accounts should be reduced by assessments for benefits levied against adjacent property, thus giving the increment due to the existence of the service to the consumer, instead of the land-owner. The charges for services rendered should be enough, and only enough, to pay the entire cost of the service, under public ownership, and the cost, plus reasonable profits, where private ownership prevails.

Mr. John R. Commons, of New York city, Secretary of the Taxation Committtee of the National Civic Federation, agreed with Mr. Foote that the exemption of the physical property of public utilities is desirable, saying that it is absurd to exact a $50 car license fee and then complain because people have to stand up; but under our present general property tax, which assumes that all property shall be taxed uniformly, and with the high state of feeling against private corporations, it is difficult to make any headway with a proposition to exempt any of the property of such companies. With municipal ownership and private operation such exemption is possible. As to taxing municipally-owned property, it is simply taking money from one pocket and putting it into the other.

The economic aspects of the "Taxation of Franchise Values" were presented by Prof. Edwin R. A. Seligman, of Columbia University, who showed how the franchise tax had become to be regarded as the best means of making corporations pay their share of the public burdens. Mr. Wheeler H. Peckham, President of the City Club, of New York, would brush away all elaborate definitions and discussions of franchises and franchise taxes, and would allow no more than a fair rate of interest on capital invested in municipal service companies. Quotations of 140 on Metropolitan Street Railway stock are a disgrace, he declared, to the State of New York. The fares should be reduced, or else the surplus profit should be paid into the city treasury. Ex-Senator John Ford, author of the Ford franchise tax bill in New York State, explained how the original simple provisions of that bill, merely amending existing statutes so as to make franchises real estate, and thus taxable, had been made into a complicated law. He believed that the recent decision of a lower court did not render the whole law unconstitutional, but merely restored it to its original condition, under which assessments were to have beeen made by local assessors.

REFERENDUM AND LABOR QUESTIONS.

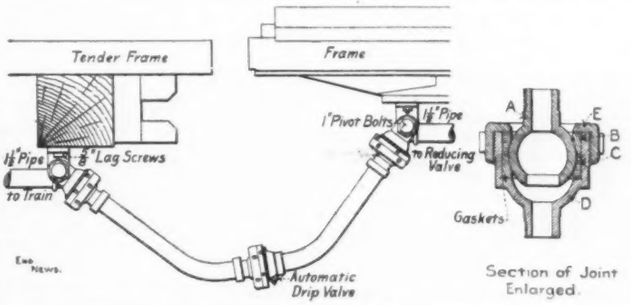
Mr. Raymond V. Ingersoll presented an excellent review of "Labor Clauses in Franchise Grants." Mr. Geo. H. Shibley, chairman of the National Federation for Majority Rule, and Mr. Eltweed Pomeroy, President of the National Direct Legislation League, made enthusiastic and forcible pleas for the referendum and initiative as a matter of justice and good government, and as an aid to municipal ownership.

A NEW FLEXIBLE METALLIC JOINT.

We illustrate herewith a new flexible metallic joint which is said to be steam, air, water and oil tight, and to ensure positively tight connection wherever movement or vibration occurs between the parts connected. The joint is the invention of Mr. J. C. Martin, Jr., Vice-President of the Holland Co., 77 Jackson Boulevard, Chicago, which company is handling the joint as one of its specialties.

The joint is of the ball and socket type, but does not depend upon internal pressure or the fit of ground surfaces for tightness, the metallic surfaces not being in contact. The end of one of the pipes to be connected is screwed to the bronze ball casting A, upon which are fitted two gaskets, B and C. These are of a special hard, non-metallic material, and their inner faces are molded to fit the ball and form its seat. The gaskets fit within the head of the bronze socket D (which is attached to the other pipe to be connected), and when the joint is put together the gaskets are held in place by a flanged ring E, screwed upon the socket head. The wear is taken by the front gasket, as the pressure forces the ball forward. When this gasket becomes worn, the ball may be disconnected, the flange ring unscrewed, and the rear gasket put in the place of the forward one. The old front gasket or a new one may then be used for the rear gasket.

So far the joints have been used only for steam-pipe connections between engines and tenders, and they are in experimental use for this particular purpose on several western railways. The arrangement is shown in the accompanying cut. Three joints are used in the connection, the two end joints giving a bend to the pipe and being attached to the engine and tender frames by special



THE MARTIN FLEXIBLE METALLIC PIPE JOINT.
The Holland Co., Chicago, Makers.

malleable iron fittings, which give flexibility and prevent any strain from coming upon the pipe. At the center joint, the pipes are bent so as to give a straight passage, and in all the joints the diameter of the opening is greater than that of the pipe. They are steam tight under pressure, and are fitted with automatic drip valves to prevent the accumulation of any moisture in the joint. This drip is a flat composition seated valve, held up by a light spring of about 5 lbs. pressure.

The metallic connections are said to occupy no more space than the ordinary rubber hose connections, and to be as readily applied as the latter. Experiments are now being made for the purpose of applying this metal pipe and flexible joint between railway cars, with straight port couplers interchangeable with the present equipment. The metal pipe and flexible joint may also be adopted as a substitute for lengths of 25 to 50 ft. of hose, three or more joints being used to give the required freedom of movement.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering.

Entered at the New York Post-Office as Second-Class Matter.
Published every Thursday
at St. Paul Building, 220 Broadway, New York, by
THE ENGINEERING NEWS PUBLISHING COMPANY

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ALFRED E. KORNFELD, New York, } ADVERTISING
M. C. ROBBINS, Chicago, } REPRESENTATIVES.
C. B. READ, Boston, }

PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 170 SUMMER ST.

FOREIGN AGENTS.

C. MITCHELL & Co, Snow Hill, Holborn Viaduct, LONDON.
RUDOLF MOSSE, BERLIN and HAMBURG, GERMANY.
JOHN F. JONES, & CIE. 31 Rue de Faubourg Montmartre, PARIS.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; 6 months, $2.50; 10 weeks, $1.00. To all other countries in the Postal Union: Regular Edition, One Year, $8.00; Thin Paper Edition, One Year, $6.75. SINGLE COPIES of any number in current Volume, 15 cents.

In requesting change of mailing address, state BOTH old and new address; notice of change should reach us by Tuesday to be effective for the issue of the current week. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 323 means that subscription is paid to the 32d week (that is the issue of Aug. 6) of the year 1903; the change of these figures is the only receipt, unless one is sent by special request.

ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

We presented last week a comparison of the New York barge canal and the Federal Deep Waterway as economic transportation routes to the seaboard; and showed, we believe, the great superiority of the larger project. We now have to suggest to the legislators of New York and to the New York commercial organizations which are pushing the barge canal scheme that they inform themselves as to the waterway which Canada has on foot.

We do not refer now to the 14-ft. navigation via the Welland Canal and the St. Lawrence, although that is by no means to be ignored. What we desire to point out is that if New York should decide to spend $80,000,000 on a barge canal, it might be rendered obsolete long before its completion by the construction of a Canadian deep waterway to the sea big enough for any of the vessels now navigating the Lakes.

We have before us a pamphlet of the Montreal, Ottawa & Georgian Bay Canal Co., of Ottawa, which proposes to construct a 22-ft. deep waterway from Georgian Bay through the French River and Lake Nipissing to the Ottawa River, and down that stream to tidewater at Montreal. By this waterway the distance from Chicago or Duluth to Montreal will be no greater than the sailing distance through the Lakes from the same ports to Buffalo, about 900 miles. Moreover, the route is not a canal. There are only short stretches of excavated channel (amounting to 32 miles in all), and the rest is open lake and river navigation. Except for the time required to pass through the locks, a vessel could make nearly as good time on this route from Chicago to Montreal as from Chicago to Buffalo. Making allowance for delays at locks, it is found that a vessel will take only about 14 hours more for the voyage to Montreal than for the voyage to Buffalo. Thus, if grain is shipped from Chicago or Duluth to Buffalo at 1¼ cts. per bushel, it is evident that it can be taken to Montreal through this waterway for not more than 1½ cts.

We respectfully submit to the New York barge canal promoters the question how their barge canal could hope to compete with such a route. Indeed, we may make the question a broader one and ask how any route to the seaboard which requires transhipment could possibly compete with a route which takes freight on board a Lake steamer at upper Lake ports, and delivers it at tidewater without breaking bulk.

It may be said that this scheme has been before the public for many years, and nothing has come of it. The same thing might be said of many great enterprises which have finally, after years of agitation, been taken up and carried to completion. At the present time, from such information as reaches us, it is at least certain that the project cannot safely be ignored. Considerable work has been done on surveys, and estimates have been made which show a cost of construction for the entire work of only $68,000,000. English capitalists are said to stand ready to finance the enterprise whenever the Dominion Government will agree to guarantee the company's bonds. That such a guarantee will be given at the next session of the Dominion parliament is said to be quite probable. Conservative estimates of the traffic which such a route could command show that it should earn sufficient from tolls to pay the interest on its cost from the start, with enormous possibilities of increased traffic in the future, in view of the coming development of the great Canadian Northwest.

From an engineering point of view, disregarding for the moment political boundaries, there can be no doubt that the Ottawa route is by far the best for a deep waterway from the upper Lakes to the sea. So far as export traffic from the Northwest to Europe is concerned, it offers by far the shortest possible route, and practically its only drawback is the dangers of navigation of the St. Lawrence Gulf. On the other hand, it is to be remembered that the great bulk of the products shipped from the West eastward by the Great Lakes is consumed in the cities and towns of the Middle States and New England, and only a comparatively small proportion is exported. From this point of view the Ottawa Canal would be less advantageous to either the Western producer or the Eastern consumer than the Federal deep waterway via the Oswego route.

We may point out, however, a possible outcome which the advocates of the New York barge canal will do well to consider. If the barge canal plan should succeed in the legislature, and be adopted by the people, Canada would almost certainly follow with a guarantee of the Ottawa waterway, and it would be completed and open for business probably as soon or sooner than the New York canal. With its completion the West would be well enough satisfied so that its support for a Federal deep waterway could no longer be counted on in Congress. New York city would lose to Montreal and New England ports a large share of its export trade, and would be obliged, in order to partially save the situation, to build a 21-ft. waterway from the St. Lawrence down Lake Champlain to the Hudson at a cost of a hundred million dollars, more or less. Such a route would serve admirably for domestic trade; but we venture to respectfully inquire how such an outcome would suit Buffalo, which is now so strenuous in its opposition to the Federal deep waterway. The fable of the boy who tried to pull too big a handful of candies from inside a narrow vase would seem to appropriately fit such a case.

Since the above was in type, the barge canal question has assumed a new aspect through the presentation of a report by State Engineer Bond giving a new estimate of the cost of the barge canal. This report was made in response to a resolution adopted by the Assembly on Feb. 10, inquiring whether the increased cost of labor and materials since the barge canal surveys and estimates were made in 1900 would not cause an increase in the estimated cost of constructing the canal, and whether an additional allowance should not be made to provide against unforeseen contingencies.

Mr. Bond's report answers in detail the various questions embodied in the Assembly resolution, and raises the estimate for the barge canal proper $5,900,984 on account of increased cost of labor and materials, and $4,365,454 as an additional allowance for unforeseen contingencies.

Besides this, it will probably be a measure of legislative necessity to provide for enlarging the Champlain Canal to accommodate 1,000-ton barges, and including this and necessary improvements of the Hudson and Niagara Rivers, which may or may not be done by the Federal Government, brings the total estimated cost of the barge canal improvement at present prices of labor and materials to $100,562,993.

This sum, it is to be noted, is about double the amount originally estimated as the cost of the barge canal in 1896 by Major Symons; and when the Greene Commission made its report in favor of the barge canal in 1899, the estimate of cost was only raised to $62,000,000.

With the estimate now standing at over $100,000,000, and with the knowledge that for double this sum the entire lake shipping could be brought to tidewater, we should suppose that even the most ardent supporters of the barge canal would begin to doubt the soundness of their enterprise. To pay one hundred million dollars to build a channel merely for enlarged canal boats, when for double that sum a ship channal could be opened to connect the Great Lakes with the ocean seems on the face of it to be a poor business proposition.

It may be possible for a bill bonding the State for $100,000,000 for this purpose to be forced through the legislature; but that the voters of the State will reject such a measure if it is submitted to them, must be clear to every unprejudiced student of the situation.

In our issue of Dec. 5, 1901, we noted the transmission of electric power in California over a distance of 222 miles. The transmission was a temporary one, being made up of a combination of the systems of the Bay Counties Power Co. and the Standard Electric Co., while the power house of the latter company was under construction.

We learn from the Stockton, Cal., "Independent" of Feb. 18 that a still longer transmission system is now temporarily in operation in California as a result of a break in the pressure pipe line supplying the Standard company's power house at Electra Cal. The total distance of transmission is about 300 miles, the route being from the Bay C unties power house at Colgate, to the city of Oakland, a distance of 142 miles and thence over the lines of the Standard Co. to the Lightner mine near Angel's, Cal. This is doubtless the greatest distance over which the commercial transmission of power by electricity has ever been undertaken.

A curious example of the errors into which the non-expert critic is apt to fall when he undertakes to discuss the technical details of railway operation is afforded by current criticisms of the train dispatcher's action in connection with the recent Westfield collision. As may be remembered, the train dispatcher gave orders to have a suburban train run on the middle track, which was usually reserved at that hour for express trains, and sent a train order to the express train which followed, notifying the engineer and conductor that the suburban train was running on the track ahead of them. This order was sent to the station back of the point where the suburban train crossed over onto the express track. The stationmaster put out the train order signal, but, as our readers will remember, the express engineer ignored this, as he later ignored the block signals set against him.

At the coroner's inquest the dispatcher was asked why he did not give the order to the engineer when he started out from Jersey City, instead of relying on stopping him at a way station for the order. He replied that the railway company's rule required a train order to be sent to the station nearest the point where it would take effect. Now comes forward a critic in the "New

York Times" and urges that this rule should be amended to provide that the order should be delivered to the train at the last regular stop in advance of the one where the order is to take effect. The critic sees the risk that an engineer will fail to see a train order signal and he forgets all about the other risk that an engineer might forget the train order after receiving it. He is doubtless unaware that even under the present system, with train orders given engineers as short a time as possible before they are to execute them, the forgetting of orders is one of the most common sources of accident. In the last quarterly accident report of the Interstate Commerce Commission it is stated that during the three months ending Sept. 30 last, "the forgetting of telegraphic orders by the men who had the orders in their pockets or immediately before their eyes, was the cause of four collisions causing a property loss averaging over $17,000 each.

The fact is that, even with train orders given as close as possible to the points where they are to take effect, reliance on the memory of engineers and conductors is one of the weak points of the train order system of operation; and it is one of the strong points of the block system that it eliminates this reliance on memory as the sole safeguard to keep trains apart. The engineer does not have to remember the order of the semaphore. It gives him one positive command and his duty is to immediately obey. It is probably true that an engineer running under block signals will be on the whole less vigilant in watching for train order signals and rear flagmen, than one running under train order signals alone. He knows that these are but additional safeguards, and the block system is the main reliance. A vigilant lookout, however, is under any system the first duty of the engineer, and under either system experience shows it to be safer to run the risk that an engineer will miss signals than to display them to him so far in advance that he will have a chance to forget them.

The many eloquent arguments on both sides of the municipal ownership question at the convention held in New York last week will exert far less convincing influence in many quarters than the appalling epidemic of typhoid fever at Ithaca, N. Y., believed to be due to a polluted water supply furnished by a private company, and the overwhelming vote of the citizens of Ithaca on March 2 (1,335 to 30) in favor of municipal ownership. A few years ago there was a hard but futile struggle for municipal ownership at Ithaca; but in the face of the bitter experiences of the past few weeks the people have arisen almost as one man in a demand for public control of this vital necessity. We do not mean to say that the Ithaca epidemic would not have occurred under municipal ownership, but it is generally acknowledged that sanitary considerations govern in the management of water supplies owned by cities much more frequently than in company-owned water-works. Whatever may be the actual facts, the unfortunate experience at Ithaca will be set down by the public as a very long and black mark against entrusting the business of water supply to private companies.

SOME HINTS ON POWER DRILLING IN MINE STOPES.

It is a most common thing in reading a description of mining operations to run across some such statement as this: "We were compelled to give up the use of machine drills in stoping, as hand drilling was cheaper."

It is seldom that the writer explains why power drills proved a failure in such stopes, although they are decidedly economic in driving cross-cuts, headings and the like.

In tunnel and shaft sinking work, drills of a large size mounted on a bar are used. It naturally follows that, already owning such drills, the mine superintendent tries to use them in overhead stopes, often with discouraging results. The trouble generally is that in drilling through the ore body, seams are encountered which tend to deflect the drill, causing it to bind. Forthwith the miner picks up a sledge and strikes the drill viciously, often breaking some part of the machine in his effort to loosen the drill. If the seams are numerous the miner is thus engaged more than half his time in pounding the drill; and very often a hole is completely lost through inability to drive the drill deep enough on account of its binding. The most natural thing in the world then is to cast aside the power drill entirely, and in so doing an expensive mistake is often made.

If instead of mounting the drill on a bar, it be mounted on a tripod, the trouble due to binding may often be done away with entirely, for the very simple reason that the moment binding begins, the whole machine may then be moved

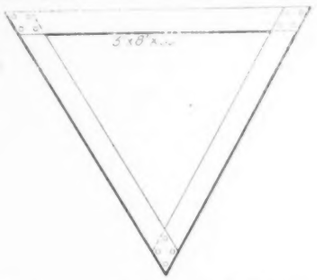

Fig. 1. Wood Triangle for Drill Tripods.

slightly by raising or lowering one of the tripod legs. This slight change of drill alinement may be made by the chuckman, often without stopping the running of the drill at all.

A tripod in overhead stoping, however, cannot be quickly or readily set up and moved about because of the irregularity of the broken rock surface upon which it stands. This difficulty may be easily overcome by making a rough platform of lagging which can thus be used over and over again.

We would suggest also that a wood triangle, shown in Fig. 1, would serve the same purpose as a platform even better. Such a triangle has been used to excellent advantage in open-cut rock work. Our next suggestion for facilitating drilling in seamy ground is to make the short bits, which are used first, larger in diameter than the longer ones. Any one familiar with drill running knows that the deeper the hole gets, the more frequent and troublesome becomes the binding of the drill in seamy rock, or rock of unequal hardness.

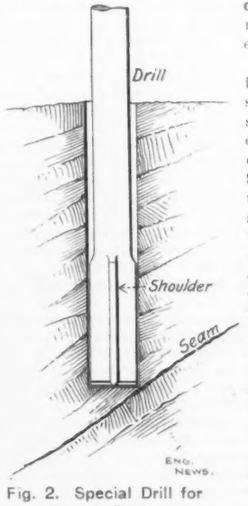

Fig. 2. Special Drill for Seamy Rock.

Another expedient is to use drills of special form, having shoulders or wings extending up the drill-shank for 6 or 8 ins. from the cutting edge, and of diameter only a trifle less than the bit, so as to fit the hole quite snugly for these 6 or 8 ins. These wings check the tendency of the cutting edge to follow the slant of any seam encountered, as will be seen in Fig. 2.

In the copper mines of Lake Superior, the native copper causes a great deal of binding, which grows worse with increased depth of hole. The drill runner knows that the first foot or so in seamy rock may be easy running, but after a certain depth is reached the trouble begins. Then the only thing to do is either not to drill deep holes (say only 3 to 4 ft. deep), or to struggle ahead in spite of the numerous delays. A shallow hole is inefficient, a deep one is costly; the miner must set the one against the other, and split the difference.

If a small drill is started in a larger hole, there is still some danger of binding due to the failure of the small drill to follow the center of the large hole. The small drill crowds off to one side. Even so, it does not stick so frequently and persistently as in holes of uniform diameter. A collar might be provided for the smaller drill, to center it in the hole at the start, although there are some practical objections to the use of such a collar. Finally, we come to the weight of the power drill used. In narrow stopes the large size ordinarily used is entirely "out of the running," because it cannot be set up and handled at all in a very confined space. Then one of the small "Baby" drills, weighing 175 lbs., tripod and all, may be used to advantage. It will take some little time and judgment for a miner accustomed to the large drill on a bar to learn how best to handle the "Baby" drill on a tripod. Such a drill when properly handled, however, will readily drill 40 ft. in 7 hrs. in quartz full of slips; and two men using hand drills in the very same kind of rock have been known to stope just half as much ore per shift as they did afterward using the "Baby" drill on a tripod.

Many mine managers are too ready to accept the verdict of old miners relative to the value of power drilling in stopes. The miner, as a rule, is not a very patient man, and becomes easily disgusted with a machine if it fails to work satisfactorily right away. For this reason the boss or manager can spend time to no better advantag than in standing right by a new machine, or an old one, in new ground. He will then frequently discover a cause of trouble that a less intelligent or less interested man would never see.

LETTERS TO THE EDITOR.

Credit for the Design of the Elevator Plant for the Prudential Buildings.

Sir: In your issue of Feb. 5, in the article, "The Evolution of the Hydraulic Elevator," by Mr. Charles L. Duenkel, the statement that: "the writer while in the employ of this company, designed and superintended the erection of the entire plant," not only assumes credit which does not belong to him, but does injustice to nearly, if not all, the engineering staff of the Otis Elevator Co. The statement, therefore, should be corrected.

While Mr. Duenkel was in the employ of the Otis Elevator Co. he was but one of a numerous engineering staff and as such had to do with the various details of the work of the installation in question under the direction of the chief engineer. The credit for the designs of the machines themselves, however, and details, such as valves, accumulators, etc., belongs to others and the general credit belongs to Mr. Thomas E. Brown, chief engineer, who is responsible for the design and construction of the entire plant.

Although Mr. Duenkel is no longer in the company's employ, the drawings which you were permitted to reproduce were loaned to him through courtesy to enable the preparation of his article, and it is surprising that he should so take credit which does not belong to him.

Yours truly, Albert S. Bard,
Secretary Otis Elevator Co.

71 Broadway, New York, Feb. 24, 1903.

(Proof of the above letter was submitted to Mr. Duenkel, and we append his reply as follows:—Ed.)

Sir: Referring to my article "The Evolution of the Hydraulic Elevator" I note an exception has been taken to an expression contained therein, reading: "The writer, while in the employ of this company, designed and superintended the erection of the entire plant."

It is the universal practice in all engineering offices where contracts of the magnitude of the one under discussion are worked out, to utilize, as far as possible, the skill of the entire staff of engineers in the employ. This method was employed in this contract. I desire to state that the general designs of this plant were drawn up by me under these conditions, and were approved by Mr. Thos. E. Brown, Chief Engineer of the Otis Elevator Co., whose skill as an engineer I allow no one to hold in higher respect than myself. It will be clear that, under the well-known conditions above described, my statement is one of fact, and the exception taken has no tangible reason for its expression. Yours truly,

Chas. L. Duenkel.

420 Liberty St., New York, March 2, 1903.

The Federal Deep Waterway and the Barge Canal.

Sir: Your article in issue of Feb. 26, making comparison of the proposed New York Barge Canal and United States Deep Waterway, should receive the attention its importance demands, not only from those most deeply interested, but also from the public at large.

It seems clear that the Eastern, Middle and Western

states, as well as the Southern coast states, should as a unit favor the short Deep Waterway route from the eastern end of Lake Ontario to New York city; as a national measure I believe it to be a great and a necessary one, and one on which the United States would be amply justified in expending one-half the estimated cost, or $100,000,000. There can be no doubt of the exceedingly great benefit along many diversified lines to be received from a waterway between the Great Lakes and the Atlantic Ocean, provided such waterway be large enough to accommodate all lake and coast carriers of freight and passengers.

When the natural inland waters via the Albany and Oswego route will furnish such a large proportion of the proposed canal, with the resultant saving in first cost and the equally important saving in time to traffic, it seems that there can be no real question as to which is the better plan—a large channel for all lake craft and only 64 hours from Buffalo to New York, or a small channel for 1,000-ton barges, taking 140 hours between the same points, even if the former is estimated to cost twice the latter.

It is well known that Canada has always taken the lead even with her small resources in canal construction, and there is not the slightest doubt but that she will continue to expend many millions to develop the St. Lawrence route and to hold traffic in that direction.

The writer believes that present conditions demand the construction of the proposed deep waterway from the Lakes to the sea, and that a 1,000-ton canal would never give satisfaction to this demand, and that a small canal would be nearly as obsolete when finished as a 30,000-lb. freight car or wooden bridge has become on our Eastern railways.

Trusting you will continue to enlighten your readers on this matter, and that the great state of New York will take the initiative in the direction that will surely be for her best interests in the end, as well as for the whole lake and coast region, I am,

Sincerely yours, W. A. Doane, City Engr.

Meadville, Pa., March 2, 1903.

Gas Engineers in the Service of Municipalities.

Sir: Being a gas engineer, I was particularly interested in the first two "Editorial Notes" in the Engineering News for Feb. 12. The idea that any boycott against municipal gas works existed among gas engineers is a new one to me, and as far as my knowledge goes is without foundation.

It is true that in recent cases of proposed purchase of gas plants by municipalities, the latter have had trouble to secure expert advice, but this was because their contention has been that the value of the property was merely the value of the plant as partly worn-out machinery, a view which no good engineer could honestly maintain. The same reason of "no case" accounts for the same trouble in securing expert advice in the attempts at price regulation that have been somewhat frequent of late. In one such case the municipality did obtain the services of a fair-minded engineer, and he proved a better witness for the gas company than for the city. I have not heard of his having been boycotted for this appearance as a municipal witness.

As far as employment in municipal gas works is concerned, it is probably true that nine engineers out of ten prefer to work for a company rather than for a municipality, because the element of politics apparently cannot be entirely eliminated from municipal undertakings. There seems to be a great deal of the same feeling even in Great Britain, in spite of the large number of municipal plants in that country. That there is, however, no prejudice in the United States against engineers of municipal plants is shown by the fact that one of the four members of the Council of the American Gas Light Association elected at the last meeting is the engineer of the largest municipal gas plant in the country, since the Philadelphia works have been leased to a private company, whose whole service has been with the municipality, as was that of his father before him.

Turning now to the second of the two "Notes," the course in "Gas Engineering," advocated therein, would not be a remedy for the condition of affairs that you assume to exist. No college can turn out gas engineers any more than it can turn out civil engineers, for instance, and any attempt to squeeze into the four years' work special gas engineering subjects would only result in crowding out foundation studies, the lack of which would seriously handicap the would-be engineer. A good course in general chemical engineering is probably the best start a man can have for a career as a gas engineer, and he cannot afford to specialize before he leaves college if he is to show forth the best results. Yours truly,

Alfred E. Forstall.

58 William St., New York City, Feb. 21, 1903.

A Word for the Contractor.

Sir: As one who has prepared numerous contracts in which my own specifications were incorporated, but all of which were revised by one of our most logical thinkers, and which resulted in a diversity of bids: as one who has supervised the execution of work according to the "cast-iron" contracts and specifications prepared by an able and very energetic engineer, which frequently resulted in losses to the contractor—in one case of $70,000; and as one who later has supervised the execution of work according to the mutual agreement (generally verbal, with unit prices in writing), between the contractors and a most alert and lovable engineer, by which the contractors were at least reimbursed for expenditures made on account of the work—I wish to add my confirmation of the last paragraph of your editorial on "The Relations Between Engineers and Contractors" in your issue of Feb. 12.

My experience has been that ignorance, dishonest pretension to knowledge, error and oversight in the premises of either of the contracting parties or of both, have always been in evidence; that the engineer usually tries to hold the contractor to the work for the consideration mentioned in the contract, while the contractor insists upon a desideratum for all work not clearly specified. I believe, therefore, the time has come when, in dealing with contractors, engineers must think and act *compensation* and must use the term in contracts instead of "valuable considerations," borrowed from the lawyers. Quite true, "valuable consideration" has been defined by the courts (see Johnson's Engineering Contracts and Specifications) as "some right, interest, profit, or benefit accruing to one party, or some forbearance, detriment, loss, or responsibility given, suffered, or undertaken by the other"; but the first definition of compensation in the American Encyclopædic Dictionary is "that which is given or received as an equivalent for services rendered, losses sustained, sufferings endured or in payment of a debt."

With President Humphreys, of Stevens Institute, engineers may feel confident that "because of their broader training, they can probably succeed in demonstrating that in the long run the Golden Rule does pay in the management of industrial properties." There is also a nice ring of truth in the following from Emerson's essay on Compensation:

> There is a third silent party to all our bargains. The nature and soul of things takes on itself the guaranty of the fulfilment of every contract, so that honest service cannot come to loss.

Very respectfully, Quid Pro Quo.

Scranton, Pa., Feb. 21, 1903.

Some of the Evils of Subletting Contracts.

Sir: In reading the contribution signed "A. C. E.," in issue of the 12th inst. regarding relation of engineers and contractors, it occurred to me that he is arguing from the view point of a head contractor, and while many of his suggestions are excellent and could be put in practice with advantage to both parties to the contract, there would still remain the point of friction between contractors and engineers unlubricated. The situation is this: The young assistant engineer enters upon his work with two problems to solve: First, to see that the contractor gets paid for all he does; second, to see that the contractor does all that he gets paid for.

How well these problems will be solved depends largely on the character of the assistant engineer. This intelligence, honesty of purpose, energy and judgment born of experience.

But there is another factor in the solution of these problems, over which the assistant engineer has no control. It is the head contractor and his methods. "There is the rub." I am surprised that A. C. E. should be surprised that there is so little friction between the head contractor and chief engineer. For he is apparently a man of large experience and knows a "hawk from a handsaw when the wind sets in the right direction."

In practice the contract is let to one man or firm at a fair price that would enable them to do the work well and leave a good margin of profit. But the practice in the Northwest has been to sublet the work to railroad men, if they will take it, at the price offered; if not, to sheepherders, freighters, farmers or anyone who has a conceit that he can get rich if he can get a contract, and these in turn relet portions of the work to station men. It is common for work to be done at from 35% to 50% less then the first price.

After the work has been sublet, the commissary established, and supplies priced, the head contractor returns to his home to exchange complimentary letters with the chief engineer, assured that however crude the assistant engineer might be, his account will be on the right side of the ledger in the day of reckoning.

Underpaid men do poor work. The assistant engineer who under these conditions gets ten miles of good roadbed built needs to possess the qualities mentioned above, and is apt to acquire a vocabulary more picturesque than polite, and such a one is in my judgment entitled to the salary that is lavished upon him. If he is deficient in some of these qualities, and is inclined to wait for inspiration from the "front office," there will be humps in the cuts, sags in the fills, narrow ditches, ragged slopes and many other objectionable features to mar the beauty of the landscape and injure the utility of the road. Having, as I believe, named the disease, I will leave others more competent to suggest a remedy.

Very truly yours, W. W. Amburn.

Montavilla, Ore., Feb. 20, 1903.

Concerning Penalty Clauses in Contracts and Their Enforcement.

Sir: In Philadelphia, and doubtless in many other places, specifications for public works provide that the amount charged against the contractor, for delay in the completion of the work, shall be retained, or recovered, "not as a penalty, but as liquidated damages."

To the lay mind the meaning of such a clause would appear to be that the parties agree in advance upon the sum provided as a proper estimate of the damage which will be sustained by the city by reason of the delay, such damage being seldom calculable with any certainty, even after the fact.

Thus, in a case where the contractor failed to complete, within the specified time, the coping of a wall around an intake, most engineers would probably hold that the mere fact of the city's willingness to pay for a coping upon the wall is sufficient evidence that she is damaged by each day during which she is kept out of the use of such coping, to say nothing of possible (but generally undemonstrable) damage to the unprotected wall. Or, in a case where a contractor has failed to place a fire-escape upon a public school building within the stipulated time, one would suppose that the city suffers damage (in the shape of risk) by delay, even though it cannot be shown that children have been burned for want of the fire-escape.

The legal mind, however, appears to view the matter differently, for the Supreme Court of Pennsylvania is said to have ruled, in some cases, that, nothwithstanding the existence of the clause mentioned, in the specification, it is incumbent upon the city to show that it has actually sustained physical damage; otherwise it cannot collect the sum provided. It is held also that, unless such damage be proven, the charge against the contractor for delay becomes a penalty, which is forbidden by the clause in question.

Thus, in the case of the coping on the intake wall, the court instructed the jury to give a verdict for the contractor, because the city could not show that the wall had sustained damage by reason of the lack of the protection of the coping during the period of default, or that horses had shied at the unfinished structure during that time, and admitted that the absence of the coping had not interfered with the intended use of the intake as such.

In recent specifications, I have inserted the clause: "It is hereby agreed that the sum herein fixed shall be taken as the damage sustained by reason of delay, and that the city shall be under no obligation to prove damage"; but I have no certainty that such a clause will protect the city, in law, against a suit by the contractor.

Can you or your readers enlighten me on this point?

Yours truly, John C. Trautwine, Jr.

257 So. 4th St., Philadelphia, Pa., Feb. 21, 1903.

(The question is one for lawyers to give an opinion on, we judge, rather than engineers; but we question whether a lawyer's opinion as to how the courts would construe such a provision in the contract would be anything more than a sage guess. Our correspondent's letter, however, is of a good deal of interest from another point of view. Prof. Taylor, in his letter published below, defends these penalty clauses and claims that they are not made to be enforced, and are not enforced save in the rarest cases. Here, however, we find an engineer of prominence not only defending these clauses, but trying to find a way by which he may make these clauses effective in punishing the contractor for delays. We believe Mr. Trautwine is on the right track. This old system of drawing a contract to count against the contractor at every point is of a piece with other antiquated legal customs, such as the exaction of a penal sum in a debtor's bond. If Mr. Trautwine or any one else can make these delay-penalty clauses enforceable, we shall then see such clauses framed with due regard to the rights of the contractor as well as of the party for whom the work is to be done. Otherwise contractors will not undertake the work.—Ed.)

Engineers, Contractors and Specifications: Instructions to Resident Engineers on Railway Construction.

Sir: The article in Engineering News of Feb. 12, by A. C. E., on the relation between engineers and contractors and your editorial comment on the same, was very interesting and in connection with some other recent articles on the same topic in your paper calls for some reflections.

The writer thoroughly agrees with A. C. E. in the suggestion that the technical schools should give more attention to specifications and the laws of contracts. And he is very glad to call attention to the fact that this subject is now very fully treated at our best technical schools.

The writer's own experience in regard to the want of an understanding by young engineers placed in charge of new work of their relations to their work and to the contractors corresponds exactly with that of A. C. E. Further, he can remember the uneasy feeling with which he took charge of his first piece of important work as resident engineer and how he longed for something, which something was lacking, that would help him to orient himself in his bearings towards the contractors and his duties. Well does he remember the joy he felt one day during this

anxious period when he opened a package from the office of the chief engineer upon seeing a formidable looking document entitled "Instructions to Resident Engineers" and his subsequent dejection of spirit when he found that the said instructions only pertained to the method of putting in spiral curves, which method was supposed not to be known to young engineers.

Experience soon taught the writer, however, as it did A. C. E. and others, that there were many clauses inserted in the specifications and contracts of every railway construction agreement that neither the principal contractor nor the chief engineer expected to have the smallest weight in regard to the future conduct of the work, in so far as it affected their own relations to it.

While it is certainly a waste of printer's ink, from one standpoint, to insert such clauses in a construction contract as that the railway company's chief engineer's verdict shall be the dictum of the court of last resort, for all disputes that may arise upon the work, the writer disagrees with A. C. E. and with other writers of similar import who state that such clauses add materially to the cost of the work on account of bringing about a necessity for the contractor to "bid a price about the factor of uncertainty." This would certainly be the effect of such clauses if they really misled the experienced contractor. But as a matter of fact these clauses are sized up at their true value by the experienced man, as he well knows they will not, as they ought not, hold before the courts of the land. These clauses only mislead the engineer who is a novice and the inexperienced contractor.

Neither has it been the experience of the writer that there is such a "wide range of prices in competitive bidding," as A. C. E. intimates. The writer worked some years on a system where the form of construction specifications had descended through many years of successful construction and was held to be as unchangeable as the law of the Medes and Persians. These specifications contained nearly every one of the unreasonable clauses referred to by A. C. E., and yet the writer was then and has always been amazed at the closeness of really competitive bids from really reliable contractors. On one occasion three different bids, though differing materially in the price per item, differed on the total cost of $750,000 worth of work less than $1,000.

On one occasion the writer assisted the chief engineer of an important Western railway in the revision of his standard form of construction specifications and contract. Said revised specifications contained many of the unreasonable clauses objected to by A. C. E. and others. When these blank forms were submitted to the chief attorney his criticism was framed as follows:

If I were a contractor and you wanted me to sign that contract I might not go so far as to say you expected to rob me, but I certainly would say you wanted the right to rob me if you chose to.

And yet after these revised specifications were submitted to the executive officers, who were educated men of experience, operating a successful modern railroad, these clauses were retained in the printed form of contract. The expediency of retaining these clauses, though severely criticised, was justified in their opinion on the grounds that they did not at all deceive or mislead the really responsible contractor of experience with whom the railway wished to deal. Since the men with whom the principal contractor has to deal, however—the subcontractors—are more or less inexperienced and irresponsible men—it was argued that it would give the principal contractor a better hold upon them, so that he could hold them more closely to their work, if he required them to execute this same form of contract with him that he himself had with the railway company.

The writer does not believe that the existence of these clauses in so many contracts can be justified on equitable grounds; but they are justified on the grounds of expediency. He has seen more than one obstreporous, irresponsible fellow held down to his business and made to do really good honest work to his own eventual advantage who would have given a great deal of trouble were it not for the fact that these clauses gave the engineers, seemingly at least, such absolute authority on the work.

A very large part of the railroad construction in this country has been done in the wild and woolly districts where the authority of courts of law was far in the background, very much as it was in the '49 period in California. And the men who did the rough and heavy work of railway construction had very much such lawless natures as characterized these early settlers. Such men would have had, as such men still have, little respect for the contract of equity contended for by so many of your correspondents. To control them and get good results from them it was necessary somehow to give the engineer in charge something of the same authority over his contractors that a colonel in the army exercises over his regiment in war times. And these unreasonable clauses gave the necessary authority. It did not matter even if the contractor felt sure that some of the clauses to which he had subscribed would not hold in the courts. He could not be sure but what some of those whose equity he doubted would hold. And since he had subscribed to them in order to get the work, and since he would have to go to the expense of a lawsuit in order to test their standing before the courts, he usually considered it safer to submit to the engineer's authority and to trust to the mercy of the railway company, whose policy toward him was generally determined by the attitude of its engineers.

It has certainly been the practice of most of the leading railways to pursue a liberal policy toward contractors who earnestly strive to execute their agreements; and instances where even reasonable clauses for the protection of the railway company have been taken advantage of at the contractor's expense have been very rare indeed in the writer's experience.

For example: Nearly every railway construction contract contains a clause to the effect that the time of the completion of the work is of the essence of the agreement and further that in case that the work is not completed by the time named, the reserved percentage, of 10% or whatever it may be, shall accrue to the railway company as liquidated damages. Now the writer estimates that fully 80% of such contracts as have come under his surveillance have fallen behind in the time of their execution, and some of them have taken two or three times as long to complete as the time stipulated. And yet, never within his knowledge have the railways even attempted to retain the reserved percentage, except in a single instance where the contractor's neglect of his work and his general behavior were flagrant and exasperating to the last degree.

Of course, no responsible bridge company nor equipment company will execute a contract of this nature, nor do the railway companies desire that they should. Even responsible contractors who do all their own work with high-priced reliable men that they pay on a wage basis will often times refuse point-blank to execute the standard form of contract, particularly if such a contractor has not worked on that road before so that its general policy is not known to him. A case in point is where a responsible firm takes the contract to put in the substructure of a heavy bridge. Probably every chief engineer has had the experience of having such a contractor refuse to execute the standard form of contract. In such cases the chief engineer generally readily agrees to any proposed reasonable changes in the form of contract. He only makes use of the unreasonable clauses to bring irresponsible men into line.

Thus the writer believes that as the contracting business develops and falls more and more into the hands of educated competent and reliable men, we may hope to see these clauses of doubtful equity disappear from construction contracts.

During the six months ending last September, the writer was called on to organize an engineering corps in some little haste to do a piece of heavy mountain construction. Experienced engineers for all the positions could not be had and some of the resident engineers and their assistants had to be put on the work verdant and fresh from their university training. As they were placed on the work the personal letter printed below was sent to each one for the purpose of helping him to orient himself. This work is still under construction at this writing and this letter is still in force with some eight or ten resident engineers doing some heavy mountain work:

——, Resident Engineer.

Dear Sir: If you have had much experience in construction work, perhaps a large part of what I will say to you is unnecessary; but I have known many young men in charge of responsible construction who seemed to entirely misunderstand the object for which they were employed.

You are expected to see that that part of the road committed to your care is constructed as well and as rapidly as possible. For this purpose it is necessary for you not to hamper the different contractors by exacting requirements, but to co-operate with them in every way possible to advance the work. No good set of specifications covering large construction contracts was ever written that could be without injustice rigidly adhered to in every minute detail; but all specifications should be interpreted on the broad grounds of reasonableness and common sense.

IMPORTANCE OF KEEPING CAREFUL NOTES.

For the good of the work as well as for the sake of your own reputation you should keep your notes in such shape that in case you should leave your work before its completion, whether you leave voluntarily, on account of promotion, or otherwise, the man who succeeds you can take it up where you leave off and carry it on as well as if he had been there from the beginning. To this end it is absolutely necessary that copies of all important letters, notes, etc., should be kept on file, and your notes relating to reference points, curvature, grades, cross-sections, vertical curves, quantities, classifications of material, heights of foundations, etc., should be carefully made and transferred in ink at the close of each day to a book that should never be removed from the office. It is my intention to put with each one of you a rodman and assistant of sufficient education, intelligence and helpfulness to do all the instrument work after the first week or two and assist in making and checking all calculations. Then you can devote your time to seeing that the work is done properly and rapidly. If you find you have men with you who do not render you such assistance as is here outlined, whether from inefficiency or unwillingness, you must place the matter in writing before your Division Engineer, who will report the matter to me. I mean by this to emphasize the fact that you are the man who will be held responsible for the condition and *progress* of your work.

While I shall expect that the men who are appointed to these positions will be too honorable and upright to be guilty of any questionable arrangements with contractors or others, you are hereby instructed to keep your notes so that your work can be checked up rapidly and understandingly by an impartial expert at any time.

The important monthly estimates must be certified to by both your rodman and assistant.

YOUR DEALINGS WITH THE CONTRACTORS.

Please remember that neither you nor I have authority to make contracts to carry out this work, but we are put here to carry out those made by the president. The specifications and plans have been drawn with a view of having all the work with which you are connected, except the engineering work, done by contract, but in any case where it is necessary to employ a contractor to do work on force account you should check the force and wages, and direct the work.

You are not to recognize any subcontractors as having any authority on the work except as agents of the principal contractors and all written communication to subcontractors should be addressed to them as agents of the principal contractors.

You are not in any case to give subestimates to any contractor or any one on your work either in writing or verbally. Your estimates on each section shall be made out in duplicate and turned over to the Division Engineer. They must be made out in copying ink and when they leave your office must not have had an impression taken. But at any time when the contractor's engineer or superintendent wishes to see your notes or quantities, let him inspect your books or notes in your presence and copy such entries as he chooses.

ALINEMENT AND REFERENCE POINTS.

You should not stake off your work for construction until you have assured yourself that the alinement and elevations are correct and not until you have established such reference points and bench marks as will enable you, or any one who succeeds you, to readily replace the line upon the ground at any time. The magnetic bearings and distances to your reference point monuments should be plainly recorded, and, as a rule, on hillside work, all reference points should be on the upper side of the roadbed, since both the timber and blasted material are liable to disturb them when placed below.

Such locations as this you are working on are always made hurriedly and it is rarely the case that great improvements cannot be made by shifting the line a little up or down hill, or by slightly lengthening one curve or decreasing another. By earnest study of such conditions, even where I had made the location myself, I have found instances where, even after the right of way had been cleared off and the work staked out for construction, the alinement could be bettered or several hundred dollars saved by some such slight change. Of course such a change should not be made without the approval of your Division Engineer.

Another most important matter is the correct proportioning of the waterway area for the streams, particularly for the smaller streams. Please check all the smaller openings shown on the profile by Talbot's formula, which is that the area of the waterway required in square feet equals a coefficient multiplied by the ¾ power of the number of acres drained. Take the value of the coefficient as unity for very steep ground and as 0.75 for the rolling country found along this road. If you find the waterways proposed are unnecessarily large or not large enough, please report the same in writing to your Division Engineer.

VERTICAL AND TRANSITION CURVES.

Please see that all grade breaks are rounded off with parabolic vertical curves which shall be of such length as will not make the break in the rate of grade per station greater than 0.2 ft. in summits and not greater than 0.1 ft. in sags.

In spiraling curves please use the Holbrook spiral.

If tangents are long enough between curves to allow it:

*On curves of degree	2½	to	5	use 60-ft. spiral.
" " " "	5½	"	7	" 30-ft. "
" " " "	7	"	10	" 24-ft. "

In case the tangents are not long enough to use these spirals, use the longest spiral you can get in. I will send you tables containing the elements of 60, 30, 24 and 18-ft. spirals. The work must be staked out on the spiraled curves.

SPECIAL DETAILS THAT YOU ARE TO LOOK AFTER.

The drainage of the roadbed should receive a large share of your attention. In all likelihood the part of the road under your care will not for many years receive the intelligent attention in detail that you should give it. Both surface, or right of way ditches, and the cut ditches should be carefully laid out and constructed and finished up as the work progresses. Do not allow your contractors to put the ditching off to the last.

Please pay particular attention to the keeping away of running water from the toe of embankments; to the dressing of the slopes of cuts; to the removal of all rock in cuts, particularly in earth cuts, to the required slope and width

*The line had been located with a minimum tangent between reversed curves of 300 ft.

and to the 1-ft. depth below subgrade in rock cuts so that the cut ditches and the line of view will not be obstructed; to the placing of stakes and the taking of cross-sections at all plus stations where marked irregularities occur in the surface on *either side* of the roadbed; to the quality of the stone and timbers that go into your structures; and to the neatness with which your culverts, retaining walls, and abutments fit the embankments.

When a cut has been staked out and rock is encountered after digging down a few feet, the centers and levels should be rerun and the cut restaked for a rock cut, but this should not be done until the earth is removed down to the rock according to the original lay out.

RECORDS AND ESTIMATES.

You are to keep in your office in ink a record and estimate book. In the estimate book you are to keep the detailed accounts by which you arrive at all monthly and final estimates.

The principal roadbed and slopes adopted on this work for single track are:

	Roadbed.	Slope.
Rock cuts	18 ft.	¼ to 1
Shale or slate	18 "	⅓ " 1
Earth	20 "	1 " 1
Wet summit earth cuts	22 "	1¼ " 1
Embankments	16 "	1½ " 1

I will send you tables of level cuttings per 100 ft., for each ¼-ft. for these roadbeds and slopes to be used in computing monthly estimates before the final quantities are calculated. It will be accurate enough for monthly estimates to interpolate by inspection in the tables.

For calculating the final quantities I wish you to adopt the method of averaging end areas applying a prismoidal correction. I attach below a sample sheet of the manner in which you will please keep your notes for ordinary work. It is better for many reasons that the difference in the average depth of one cross-section and the next should not be more than 6 ft.

Use — for fills and + for cuts. In the notes given, the roadbed in excavation is 20 ft., slope 1 to 1; in embankment, roadbed 16 ft., slope 1½ to 1.

The "haul" on material should be calculated by mass diagrams drawn on the profile after the manner explained in the text-books of Webb or Allen.

LEFT-HAND PAGE OF RECORD BOOK.

Sta.	Elevation.	Grade.	Cuttings Left.	Cuttings Center.	Cuttings Right.	Average.
675....	954.6	944.2	+ 14.8 / 24.8	+ 10.4	+ 7.2 / 17.2	+ 10.7
+ 42....	948.6	943.8	+ 7.2 / 17.2	+ 4.8	+ 3.2 / 13.2	+ 5.0
+ 60....	945.2	943.6	+ 2.8 / 12.8	1.6	0.0 / 10.0	+ 1.5
+ 82....	942.2	943.4	0.0 / 10.0	— 1.2	— 3.2 / 12.8	— 1.4
676....	936.4	943.2	— 5.2 / 15.8	— 6.8	— 9.2 / 21.8	— 7.0

RIGHT-HAND PAGE OF RECORD BOOK.

Areas, sq. ft. Excavation.	Areas, sq. ft. Embankment.	Contents, cu. yds. Excavation.	Contents, cu. yds. Embankment.	Remarks.
328.40	.....	.....	....	.....
124.96	.....	343.2	....	.....
32.24	0.0	51.0	....	.....
0.0	25.28	8.8	6.8	.....
.....	185.44	....	65.0	.....

Sum up whole cut.. .. ..

Yours truly. W. D. Taylor.
Professor Railway Engineering.

Madison, Wis., Feb. 16, 1903.

Salaries of Mining Engineers and U. S Geologists.

Sir: Will you kindly enlighten me concerning the salaries of mining engineers, on an average, and of members of the U. S. Geological Survey, or tell me where I can find such information?

Yours respectfully, Charles T. French.
10 Summer St., Somerville, Mass., Feb. 27, 1903.

[Reference to Vol. I. of the last annual Report of the Director of the U. S. Geological Survey shows that annual salaries average as follows: Geologists, $3,425; Chemist, $3,000; Geographers and Topographers, $2,300; Paleontologists, $2,000. Salaries of other members of the Survey are not recorded in the Report.

Regarding the salaries of mining engineers no definite answer can be given, since they range from about $75 a month, which the young graduate receives as a mine surveyor, assayer or the like, to the $100,000 a year said to have been paid an American mining engineer in charge of a group of gold mines in the Rand, Africa. It is quite certain, however, that the members of no other branch of the engineering profession receive as large salaries as do mining engineers of established reputation. This is in part due to the difficulty of getting the highest class of men to live in out-of-the-way regions, and partly to the great responsibility for business success or failure resting upon the shoulders of mining engineers.—Ed.]

Notes and Queries.

T. U. T., Austin, Tex., writes:

Please give me a definition of lumber as it would be interpreted in an engineer's contract. What does it include? Would it include piles, ties (not sawed), etc.?

We should say that piles and ties would not be included in the term "lumber," as commonly used; but the question is a nice one for lawyers to fight over.

A STRESS DIAGRAM FOR WATER TANK HOOPS.

By Ballinger & Perrot.*

The accompanying diagram has been computed by us for the purpose of figuring the size of hoops for cylindrical wooden tanks. In addition to being able to determine the stress in the hoops, we have placed on the same sheet the area of rods as well as the capacity of circular tanks in gallons per foot of height (omitted here—Ed.). We have found it very convenient in figuring tank capacities to assume that the water height is about 1 ft. less than the length of the stave, and that the mean diameter is approximately 1 ft. less than the outside diameter at the bottom. Tanks figured on this basis will be accurate enough for all practical purposes.

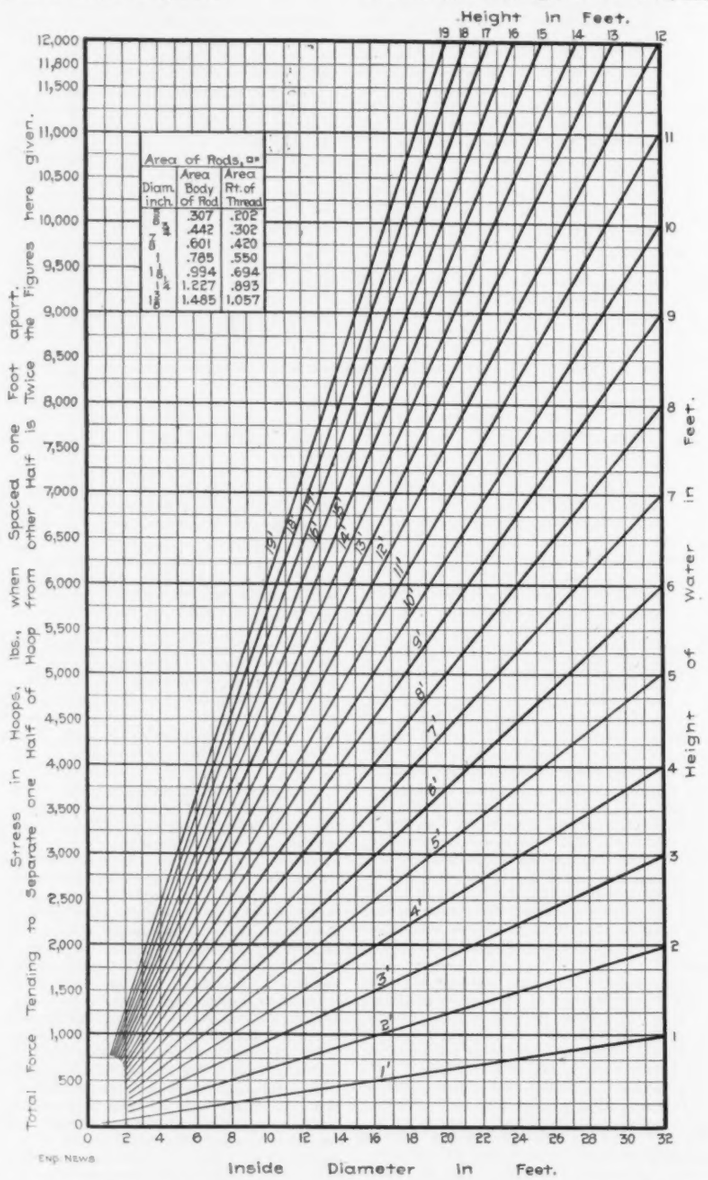
Height in Feet.
Area of Rods, a*
Diam. inch.
Area Body of Rod
Area Rt. of Thread
⅞ .307 .202
¾ .442 .302
⅞ .601 .420
1 .785 .550
1⅛ .994 .694
1¼ 1.227 .893
1½ 1.485 1.057
Total Force Tending to Separate one Half of Hoop from other Half when Spaced one Foot apart. Stress in Hoops, lbs., the Figures here given.
Height of Water in Feet.
Inside Diameter in Feet.
Eng. News

DIAGRAM FOR COMPUTING STRESS IN HOOPS FOR WATER TANKS.
(Hoops to be figured for unit stress of 12,000 lbs. per sq. in.)

The diagram is worked out on a basis of hoops spaced 1 ft. apart. In practice, of course, they are put closer together than 1 ft. at the bottom and farther apart than 1 ft. towards the top.

In determining the size of the hoops, of course it will be necessary to determine the approximate spacing, and then from the table multiply the stress for the 1-ft. spacing by the actual spacing

*Architects and Engineers, 12th and Chestnut Sts., Philadelphia.

In the article "Computing the Strength of Concrete-Steel Beams," by Mr. Edwin Thacher, M. Am. Soc. C. E., published in our issue of Feb. 12, 1903, an error occurred in printing the diagram, Fig. 1, and in formula (10), forming part of Table III. The correct cut is given herewith. The correct formula is as follows:

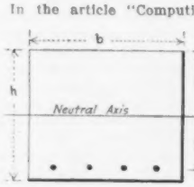

Fig. 1.

$$w_1 = \frac{12 \cdot S}{4.5\,l^2}\left\{\frac{E_c}{E_s}\cdot\frac{x^3}{y} + 3Ay\right\}. \quad (10)$$

in feet, or fraction thereof, to determine the stress in any particular case. We have found from our experience that a flat hoop should be used at the extreme bottom of the tank and round ones above. The flat hoop gives a better bearing area on the staves where they are weakest, due to the groove for the bottom of the tank, the wood at this point being somewhat less in thickness.

Also, we find that the use of wrought iron is preferable to steel for hoops, and use a unit stress of 12,000 lbs. per sq. in. in the hoops. In practice, also, we find it better not to use a hoop of less diameter than ⅝-in. The particular advantage in using the round hoops over the flat ones is that they are less liable to rust out, and tank manufacturers in general are commencing to see the superiority of the round hoops.

THE GREAT HEMATITE DEPOSITS OF BRAZIL.

In view of our enormous deposits of iron ore in the Lake Superior districts, we are apt to minimize the importance of all other iron ores. But it is altogether probable that the mountains of magnetite in Sweden just being opened up, the huge deposits of hematite in Brazil, not yet worked, and other similar bodies of iron ore will play an important part in the industrial history of the United States.

In the December bulletin of the International Bureau of American Republics we find an interesting description of the iron deposits of Brazil. Of these by far the most important are the massive hematite beds of Pico d'Itabira do Campo. The most important railway in Brazil, the Central Railway, crosses the ore zone.

The hematite occurs in beds often 90 to 150 ft. thick, carrying 66 to 70% Fe, with 0.37% $Si O_2$ and 0.023% $H_3 P O_4$.

Respecting the outcrop of Itabira, Mr. W. H. Herdsman, of Messrs. E. Riley & Co., says:

> Although one hears frequently of mines and deposits which are described as being "mountains of iron," I have never in my 25 years' experience, until I visited Itabira, found one which even remotely justified the title. The Pico d'Itabira is, however, a real mountain of iron, and doubly remarkable in the uniform purity of the mineral, for from the moment of arrival on the iron-ore area I did not find one single fragment of stone which was not mineral, not one single piece of mineral which was not of the same pure and rich quality as is evidently the whole of the gigantic body of ore. I use the work "gigantic" advisedly, for there can be little doubt that not less than 10,000,000 tons of the purest ore known is found out-cropping here at a single point, and when one remembers that a similar outcrop is found some 95 miles distant and that other lodes and ore bodies are found at numerous intervening places, while the whole adjoining country is covered with iron ore in every direction, the immensity of the Brazilian ore deposits becomes very evident.

THE PANAMA CANAL.*

By George S. Morison, M. Am. Soc. C. E.†

On March 5, 1902, a paper‡ on one of the most important features of the Panama Canal was presented by the writer. That paper was confined to a single detail, although a very important one. The present paper covers a larger scope, and takes up the principal features of the canal.

The Isthmian Canal Commission, in its report, tried to place the two canals, Panama and Nicaragua, as nearly on the same basis as possible; eliminating from each scheme special advantages and economies which might be applicable on one, but could not be on the other. There were several points on which the writer differed from his colleagues, and, while these differences do not affect the general conclusion, his individual views have influenced the present paper.

Much has been said of the great value of a tide-level canal and its unlimited capacity. This unlimited capacity is more apparent than real. A tide-level canal will require a tide lock at the Pacific end, and, although both gates can be left open at mean tide, so that the length of lock is not a limiting factor, its breadth and depth are. The difficulties of controlling floods are greater in the tide-level canal than in the canal with locks, and the advantage of a broad inland lake is lost. Still, the writer believes that the tide-level canal would be the better canal when done, but that the difficulties which would attend its construction, the greater cost, and especially the longer time involved, preclude its selection. In this paper both plans of canal are described, and comparative estimates given in some detail.

The locks are of enormous dimensions, and, while few engineers would doubt the feasibility of locks 800 ft. long, more than 80 ft. wide, with more than 40-ft. lift, conservatism cautions us against this great lift if it can be avoided. Partly for this reason, the writer has selected the Tiger Hill Cut-Off line for the high-level canal, which permits the rise from Atlantic to Lake Bohio to be divided into three lifts instead of two, shortens the line, and places it farther from the Chagres. The old location is not condemned, but the cut-off is preferred. The fact that by the use of an intermediate level the head of water against the dam is reduced explains the difference in the seepage figures used in this paper and those calculated in the paper on "The Bohio Dam."

GENERAL DESCRIPTION.

At Panama the actual width of the Isthmus from tide water to tide water, in a straight line, is only 35 miles. The continental divide is about eight miles from the Pacific, and in places less than 300 ft. above mean tide. Between this low mountain ridge and the Atlantic lies a hilly country, intersected by streams, the drainage of which is into the Atlantic through the Chagres River. The Chagres rises in the mountains about 60 miles east of the canal location and enters the Caribbean Sea some miles west of the Atlantic terminus of the canal. The valley of the Chagres, with the low country adjacent to it, forms a natural approach from the Atlantic side. To pass from this valley to the Pacific, it is necessary to go boldly across the low ridge of the Cordilleras. The route selected by the original French company for the Panama Canal is, in a general way, the same as that on which the Panama R. R. was built 30 years before. Subject to variations of detail, the routes are practically one, and the only possible route in this part of the Isthmus. The total distance by either railroad or canal from deep water to deep water is, in round numbers, 45 miles, of which 27 miles are in the Atlantic coastal plain and the valley of the Chagres; 12 miles are in the passage of the ridge, and the balance in the low lands near the Pacific. Of the actual distance from the Atlantic shore line to the Pacific shore line, not including the extensions into deep water, almost exactly two-thirds, being the portion north of Obispo, are within the drainage of the Chagres, and one-third in the crossing from the Chagres to the Pacific.

The Chagres is a tropical mountain stream, with the excessive variations which belong to such a river. Its maximum flood discharge is approximately 200 times its minimum dry-season discharge. The area of its total drainage basin, though not completely surveyed, is about 1,200 sq. miles. It has a comparatively rapid fall, which is greatest near the source. At the point where the canal leaves the Chagres valley to cross the divide, the bottom of the Chagres River is about 40 ft. above mean tide. The principal difficulties of the northern portion of the canal, from Colon to Obispo, lie in the control of the Chagres River; the principal difficulty on the remainder is the summit cut. In a tide-level canal, such as the original French company proposed to build, these two difficulties were virtually all. With the abandonment of the tide-level scheme and the adoption of a summit level reached by locks, the problem of water supply for this summit level was added, but, as the only source of gravity supply for such summit level is the Chagres River, the problems of the control of this river and of the use of its water to feed the canal are very intimately connected.

Besides these, there are the harbors, which present difficulties, though not serious ones, at each end of the canal; the dimensions of locks which should be used, and the changes which the construction of the canal must necessarily make in the Panama Railroad. These matters call for only brief consideration.

The dimensions of the canal itself are of the utmost importance, and no estimates can be made, even of a preliminary character, without determining them. The dimensions adopted by the French company are in a general way those of the Suez Canal. The Suez Canal is a salt-water canal throughout. The Panama Canal will be a fresh-water canal, and it will also be a warm-water canal, the water weighing 62.2 lbs. per foot, or about 3% less than the water of the ocean. The Suez Canal has a depth of 9 m., or 29.5 ft. To accommodate ships of equal size, the Panama Canal should be at least 8 ins. deeper. The Suez Canal cannot accommodate the largest class of ships; the regulations of that canal limit the draft of ships passing through it to 7.8 m., or 25 ft. 7 ins., though ships of greater draft are sometimes taken through with the assistance of tugs. The largest steamers now plying between England and Australian ports cannot and do not pass through the Suez Canal. There is a large number of ships now in service on the Atlantic, the authorized draft of which is 32 ft. or more; one of these ships would draw 33 ft. in the Panama Canal. The traffic which would pass through the Panama Canal would be of a character materially different from that which uses the Suez Canal; it would consist largely of heavy, coarse freight. As the size of a ship is, in a measure, a function of the length of voyage, it is probable that the largest class of freight carriers will use this canal. The Isthmian Canal Commission considered that the canal should have a depth of 35 ft., through which steamers drawing 32 ft. in salt water could pass without trouble, and the writer concurs in this decision.

In determining the width of the canal there is more room for difference of opinion. While the depth may be considered a necessity, width is very largely a convenience. A ship can be taken through a canal with little clearance on either side, but it must be done very slowly; a much greater width will be required if any considerable speed is to be maintained, and still more if large ships are to pass each other in all portions of the canal. The dimensions adopted by the original French company provided for a bottom width of only 22 m., or 72 ft.; the new French company adopted a bottom width of 30 m., slightly increased in rock sections, or a little less than 100 ft. The Isthmian Canal Commission selected a bottom width of 150 ft., which was somewhat enlarged on curves. The increased width on curves in so large a canal is perhaps an over-refinement, but, in view of the experience of other great works, it is probably not wise to reduce the dimensions selected by the Commission.

Colon Harbor is virtually tideless, while Panama Bay has a tidal range of over 20 ft. The plans of the original French company contemplated a depth of 9 m. below mean water at both termini, which would have made a channel of about 20 ft. at low water in Panama Bay. The plans of the new French company proposed a depth of 9 m. below low water in Panama Bay; the Isthmian Canal Commission's estimates are based on a depth of 35 ft. below mean low water in Panama Bay. A depth of 35 ft. below mean tide in Panama Bay would give 25 ft. in the canal under all conditions, 45 ft. at high water and 35 ft. for about 18 hours out of 24. In the opinion of the writer, this depth is quite as much as the demands of traffic are likely to justify.

With this preliminary statement, the main features of the canal may be described.

CONTROL OF THE CHAGRES.

The discharge of the Chagres has been made a matter of special observation by the new French company, and these observations have been verified and amplified by Arthur P. Davis, M. Am. Soc. C. E., for the Isthmian Canal Commission. While the conclusions from such studies cannot be regarded as absolutely accurate, the general conditions, of which little was known 20 years ago, may now be considered established. The greatest flood in the Chagres of which there is any record occurred in 1879, prior to the beginning of work by the old French company. The two floods of which there is the most accurate information are those of 1890 and 1893.

The area of the drainage basin of the Chagres above Bohio, the location selected by the French company for a dam, is estimated at 875 square miles. This watershed may be divided for convenience into three parts: the portion above Alhajuela, the point selected by the French company for the upper dam; the portion between Alhajuela and Gamboa, which is practically the point where the canal leaves the river; and the portion between Gamboa and Bohio. The area of the upper division is approximately 510 square miles, of the middle division 135 square miles, and of the lower division 230 square miles. The areas of the watersheds above these three points will, therefore, be as follows:

	Square miles.	Percentages.
Alhajuela	510	58
Gamboa	645	74
Bohio.	875	100

The data concerning the flood of 1879 are meager, and consist only of water marks from which the discharge has been calculated on various assumptions, while there is no accurate information by which the duration of the flood or the aggregate discharge can be even approximately determined. The conclusions, generally, are to the effect that it was in excess of 70,000 cu. ft. per second at Gamboa and 100,000 cu. ft. per second at Bohio. The general opinion has been that these figures are too high, but Mr. Davis thinks that there is a possibility that they are too low and that the flood may have been nearly 100,000 cu. ft. per second at Gamboa, and have exceeded 130,000 cu. ft. per second at Bohio. The flood of 1890 attained a maximum of 75,000 cu. ft. per second at Bohio, and that of 1893 fell below 50,000 cu. ft. per second. All these floods were of very short duration, the average discharge of the Chagres being about 2,000 cu. ft. per second at Alhajuela, 2,500 cu. ft. at Gamboa, and 4,000 cu. ft. at Bohio. The time in which the discharge at Gamboa would exceed 35,000 cu. ft. per second, or that at Bohio 50,000 cu. ft. per second, would probably not be more than ten days in 20 years. A suspension of traffic during these few days would not seriously reduce the value of the canal.

If a flood of 35,000 cu. ft. per second coming from the upper Chagres at Gamboa and of 50,000 cu. ft. at Bohio could be so regulated that it would not produce a speed much exceeding 3 ft. per second in the navigable portions of the canal the commercial requirements would be met. The canal, however, must be so designed that a maximum flood would do no permanent harm, and this means a probable discharge of 100,000 cu. ft. per second at Bohio, with the possibility that 140,000 cu. ft. per second should be provided for. A speed of 3.3 ft. (1 m.) per second could be allowed in the canal without disturbing navigation; a speed of 5 ft. per second could be allowed without permanent injury to the work.

With these conditions, a channel of 15,000 sq. ft. cross-section would carry off a flood of 50,000 cu. ft. per second without interfering with navigation, and of 75,000 cu.

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*A paper presented at the Feb. 18, 1903, meeting of the American Society of Civil Engineers, and printed in the "Proceedings" for January, 1903, Vol. xxix., p. 15.

†Consulting Engineer and late Member of the Isthmian Canal Commission, 49 Wall St., New York city.

‡"The Bohio Dam." "Transactions," Am. Soc. C. E., Vol. xlviii, p. 236; Eng. News, March 13, 1902.

ft. per second without injury to the canal. If a tide-level canal is to be built, it must either be given these dimensions in the Chagres Valley or independent channels must be provided to carry off the discharge of the river. As the canal is in the lowest part of the valley, the construction of these channels would be a matter of serious difficulty, and the simplest solution would be to make a canal large enough to take the full discharge, which would have the further advantage of furnishing a very large canal, in which navigation, under ordinary conditions, would be especially easy; this would mean a canal with a bottom width of about 400 ft. An approximate estimate shows that the total amount of excavation for such a canal between Colon and Obispo would be 150,000,000 cu. yds., about one-sixth of which is likely to be rock. This channel, however, has practically no factor of safety, and, if the flood of 1879 should be repeated, it might prove inadequate. By building the dam proposed by the French company at Alhajuela the discharge above that point could be temporarily stored, and the discharge through the lower valley kept within the capacity of the proposed canal. It may be roughly estimated that the cost of this Chagres section of a tide-level canal would be about $90,000,000. While this treatment would be heroic, it is practicable, and would be satisfactory when done.

If, however, a dam could be built across the valley of the Chagres, the whole valley would be converted into a lake of such dimensions that the currents in this lake, even during the most violent floods, would not be objectionable. This is, perhaps, the greatest advantage to be gained by using locks and a summit level. It is certainly second only to the reduction in the volume of the Culebra Cut. The further down the valley this dam can be placed, the greater will be the length of valley converted into lake. The lowest point, however, which has been found in any way suitable for a dam site is at Bohio, midway between Obispo and the terminus of the canal at Colon. A site for a dam in this neighborhood has been selected by the new French company, and the Isthmian Canal Commission concurred in the expediency of building a dam in the same vicinity. By the construction of such a dam the valley is converted into a lake between Obispo and Bohio, and this lake would extend up the upper valley of the Chagres to a distance determined by the height of the dam. The Gigante, a lateral stream coming from the west, enters the Chagres about four miles above Bohio, and near the head of this stream is a low summit admirably adapted for a spillway. The limits within which the range of the lake could be confined would be determined by the length of this spillway. The Isthmian Canal Commission has proposed a spillway 2,000 ft. long. Using the formula:

$$Q = 3.5\ h^{\frac{3}{2}}\ l,$$

we have the following results, if l is made 2,000:

Q = 50,000	h = 3.71
75,000	4.86
100,000	5.89

It would appear, therefore, that heights of, respectively, 4, 5 and 6 ft. over the crest of the spillway would pass something more than 50,000, 75,000 and 100,000 cu. ft. per second for an indefinite period. The maximum floods, however, are of short duration, and a considerable amount would be stored in the lake, as its level is raised from the normal level to the extreme height of such a flood. With the surface of the lake at elevation 85, corresponding to a bottom level at elevation 50, as used in estimating the Culebra Cut, the surface area of this lake is 28.5 square miles, or about 1,075,000,000 sq. ft. A rise from a depth of 1 ft. to a depth of 5 ft. over the spillway would represent a storage of 4,300,000,000 cu. ft., an average of 50,000 cu. ft. per second for 24 hours, or 25,000 cu. ft. per second for two days. A detailed study shows that, with a discharge of 100,000 cu. ft. per second into the whole basin, the discharge is never likely to exceed 75,000 cu. ft. per second over the spillway, and 5 ft. may be accepted as the variation in the level of the lake. Should a greater flood occur it would merely mean a little higher level in the lake, which might possibly rise to about 6 ft. above the crest of the spillway. Furtherfore, the canal through the Culebra Cut would have a cross-section, during this high water, of over 6,000 sq. ft., capable of taking off, at 5 ft. per second, a discharge of 30,000 cu. ft. per second; and the canal north of the Bohio Dam would have a cross-section of not less than 7,000 sq. ft., capable of taking off, at a speed of 3 ft. per second, 21,000 cu. ft. per second.

This general arrangement means a lake the surface of which varies from elevation 85, when level with the top of the spillway, to elevation 90, under extreme flood conditions, with a bare possibility of reaching elevation 91. It involves a spillway at Gigante and a dam at Bohio, of which structures more will be said hereafter. Comparatively little excavation would be required in any portion of the lake, the total between the Bohio Dam and Obispo being barely 2,000,000 cu. yds., of which, perhaps, one-fourth is rock, and the total cost of which would not exceed $1,000,000.

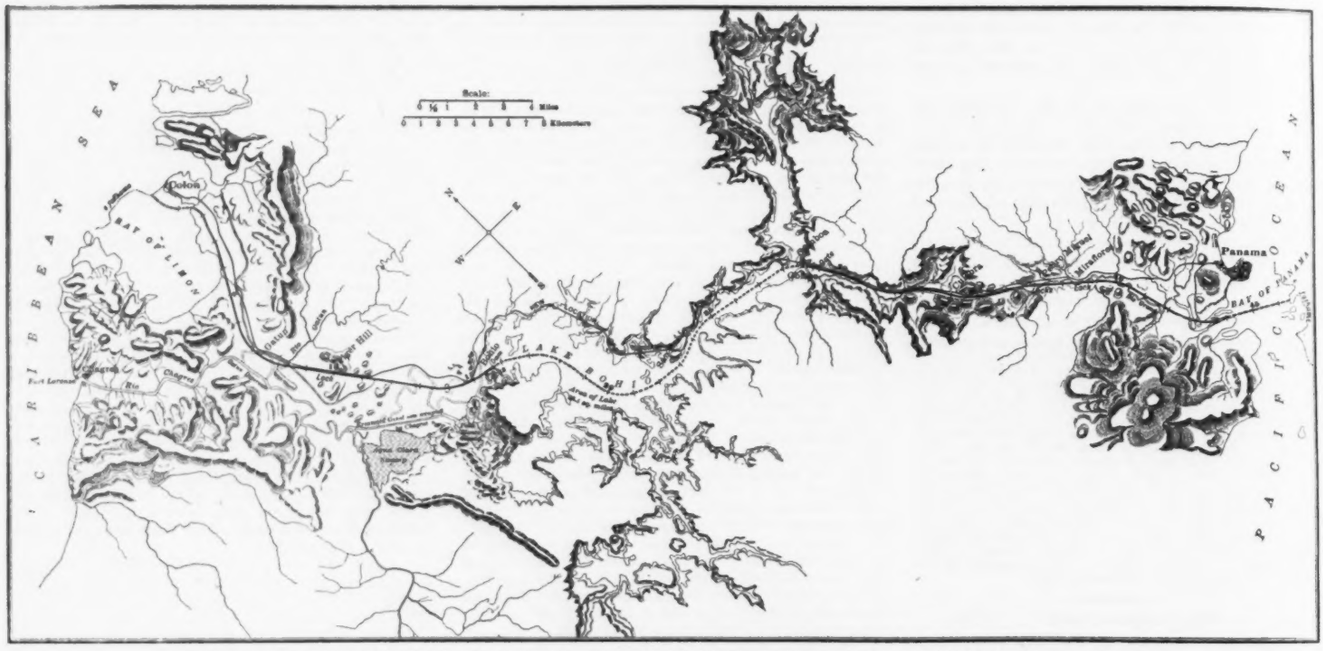

FIG. 1. MAP SHOWING ROUTE OF PANAMA CANAL SUGGESTED BY MR. GEO. S. MORISON, M. AM. SOC. C. E.

Below the Bohio Dam the old French location followed the valley of the Chagres about nine miles to Gatun, where the Chagres turns abruptly to the west and enters the Caribbean Sea some miles west of Colon. This is, perhaps, the only location for a tide-level canal. For four miles of this distance the Chagres has absolutely abandoned its old course and flows through the canal. The discharge over the Gigante Spillway will enter the Chagres about two miles below Bohio; below this point one of three courses is practicable. The same course may be adopted that is proposed for a tide-level canal, giving the canal a section of such dimensions that it could pass the flood discharge within its own limits. The valley here is generally comparatively broad, and the floods can be kept out of the canal by constructing a levee on the west side of it; this plan involves a discharge channel between the two swamps, Peña Blanca and Agua Clara, besides which a new channel for the Chagres must be dug across a neck of land opposite Gatun and about three-quarters of a mile from the canal. A location can be adopted east of the Chagres valley, between Bohio and Gatun, by which the canal can be kept a safe distance from the Chagres and for half the way at a safe height above it. This third plan has the advantage of saving 1¼ miles of distance. Furthermore, there is an excellent site for a lock at Tiger Hill, six miles from Bohio, by which it is possible to reduce the lift of the Bohio locks. This last line is preferred by the writer, and is used in this description. It is the line shown on the general map, Fig. 1. The level of the surface of the canal is maintained at 26 ft. above mean tide south of the Tiger Hill lock, the bottom of the canal being 9 ft. below mean tide. The one defect of this plan is that the water is carried a few feet above the level of the surrounding country, but there is such an enormous excess of excavation in the canal that an embankment of almost indefinite width can be built on the river side. This line joins the French location at Gatun, and the channel for the Chagres opposite Gatun is still necessary.

The problem of the control of the Chagres is absolutely solved by the construction of three works: the Bohio Dam, the Gigante Spillway and the Gatun Diversion.

WATER SUPPLY.

The only source from which a supply of water for the summit level can be obtained by gravity is the Chagres River. The French plan, which contemplated a summit level above that of the lake, proposed to build a dam at Alhajuela and convey the water by a feeder, of complicated design, from the dam to the summit. The same arrangement was proposed by Captain E. P. Lull, U. S. N., in 1875. If the lake itself be made the summit level, any such feeder becomes unnecessary, and the canal will be fed at all times by the Chagres River and the various tributaries which are intercepted by the lake. Were the discharge of the Chagres and its various effluents at all times equal to the demands of the canal, no further provision would be required. There is, however, a short period in the early part of each year when the supply is always small and sometimes inadequate. The actual demands for water for canal uses may be limited to three purposes: lockage, seepage and evaporation. Besides this, the French estimates have made provision for power, but this is hardly an actual necessity of the canal, and can be provided in other ways, if the water supply is inadequate. Furthermore, the amount of water actually needed for power is, in the aggregate, exceedingly small.

With the water in the lake at a normal elevation of 85 there will be a descent of 59 ft. to the intermediate level on the Atlantic side, and of 59 ft. to the intermediate level on the Pacific side, an average of 58 ft. Each descent is accomplished by two locks, the average lift of which, in the period when an economy of water is important, is 29 ft. These locks, according to the plan adopted by the Isthmian Canal Commission, are 84 ft. wide and 790 ft. long between gates; each lock chamber contains, therefore, 1,924,470 cu. ft. If it be assumed that ten vessels pass through the canal daily, each using two full locks of water, one ascending and one descending, the total daily consumption will be 38,488,800 cu. ft., or 445 cu. ft. per second. This amount will be reduced materially if intermediate gates are provided in the locks so that smaller vessels can take less than a lockfull of water.

The seepage will be confined principally to the Bohio Dam. There is a short piece of embankment near the Gigante Spillway, but it is of such insignificant dimensions as to be of no importance. Elsewhere, the summit lake is confined between the natural walls of mountain valleys. Estimated on the basis used in the paper on "The Bohio Dam," but with the head reduced to 60 ft., the requirement for seepage would be 28 cu. ft. per second.

To the seepage proper must be added the waste of water at the locks. This will depend very largely on gate construction, character of valves, and care of lock tenders.

A provision of 200 cu. ft. per second would seem to be ample.

The area of the lake is 38.5 sq. miles, or 1,075,000,000 sq. ft., and the evaporation over this area, taken at 0.5 ft. per month, or 0.0167 ft. per day, or 0.00000019 ft. per second, amounts to 207 cu. ft. per second over the whole area of the lake.

This makes the entire water requirement, with no provision for power, 880 cu. ft. per second. These figures will vary on different assumptions, but it is safe to say that 1,000 cu. ft. per second would be a generous supply for any traffic that is yet in sight. Furthermore, with the tendency to increase the size of ships, it is probable that the actual number of ships will be less, rather than more, than ten daily.

In a general way it may be said that, out of a total of 1,000 cu. ft. per second, 450 cu. ft. will be required for lockage, 250 cu. ft. for seepage and leakage at gates, and 200 cu. ft. for evaporation, leaving 100 cu. ft. per second for margin and power. This quantity of water, 100 cu. ft. per second, falling 85 ft., will produce about 800 HP. on the shaft of a turbine wheel.

The average monthly discharge of the Chagres at Bohio always exceeds 1,000 cu. ft. per second, except during a period of varying length in the months of February, March, April and May. It may have fallen as low as 350 cu. ft. per second for a few days. The French Company has kept daily observations at Bohio of the stage of water for about ten years. From these stages the daily rates of discharge have been calculated, and from these results it is easy to determine the deficiencies, below an average of 1,000 cu. ft. per second, which have occurred during the period of these observations. These deficiencies for nine years are shown in Table I., the last column of which shows the depth of water in the lake corresponding thereto.

TABLE I.—Showing Deficiencies in Flow of Chagres River below 1,000 cu. ft. per second from 1891 to 1902, inclusive.

Year.	Cubic feet.	Feet.
1891	2,600,000,000	2.42
1892	291,600,000	0.27
1893	1,166,400,000	1.09
1894	637,000,000	0.60
1895	864,000,000	0.80
1896	648,000,000	0.61
1897	1,728,000,000	1.61
1898	Records incomplete.	
1899	172,800,000	0.16
1900	1,296,000,000	1.21
1901	230,000,000	0.21
1902	0	0.

There are several ways to provide for this deficiency. The first would be to take it from the lake, which has an area of 1,075,000,000 sq. ft.; the last column of Table I. shows that this reduction would still leave it possible for ships drawing 30 ft. at sea to pass through. Another method would be to lower the bottom of the canal through the summit level 3 ft.; this is the plan proposed by the Isthmian Canal Commission; it would add about 1,500,000 cu. yds. to the Culebra Cut, besides increasing the height of the long retaining walls and the cost of the locks; it may be roughly estimated as adding from $2,500,000 to $3,000,000 to the cost of the canal. Another method would be by the construction of the Alhajuela Dam, proposed by the French company, by which a lake could be formed in the upper Chagres Valley, in which 15,000,000,000 cu. ft. of water could be stored. If the construction of this dam were deferred until after the completion of the other work, so that the lake could be used for transporting material, elevation 85 carrying still water almost to the site of the dam, the cost of the dam would not exceed the cost of deepening the lake, and it would have the further advantage of storing water above the dam, by which the violence of the floods below the dam would be diminished. A fourth method would be by the use of the old Yankee device of flash-boards, by which the level of the lake could easily be raised 3 ft. above the crest of the spillway, without involving any increase in the height of water during extreme floods. In the judgment of the writer, the canal should be opened with no special provision for additional water supply during the dry months, other than what would be obtained by lowering the level of the lake or by the use of flash-boards. Experience will show what additional storage is required, and, if needed, it can be more economically provided after the other works are completed than before.

Ten lockages each way daily represent the passage of 3,650 ships a year, if no two ships are ever passed together through the same lock at the same time. This would undoubtedly be done occasionally with small vessels. If 10% is added on this account, they represent a passage of 4,000 ships a year, and if these have an average of 2,500 tons, net, they represent a total of 10,000,000 tons yearly. The number of ships passed through the Suez Canal in 1901 was 3,699, the average net tonnage being 2,926 tons. It is probable that the average net tonnage will be at least 4,000 tons when the Panama Canal is opened, and that ten lockages each way daily would represent at least 15,000,000 tons.

It is important, however, to consider the possibilities of water supply for larger traffic. Of the 1,000 cu. ft. per second required for the wants of the canal, 450 cu. ft. are consumed in lockage. If, therefore, the number of lockages is doubled, representing a passage of at least 20 ships daily, the requirements are 1,450 cu. ft. per second; 30 passages would require 1,900 cu. ft. per second, and 40 passages 2,350 cu. ft. per second. The length of time when the discharge of the Chagres falls below these requirements increases with the amounts, but in no instance of which we have any record has it fallen below the maximum requirement of 2,350 cu. ft. per second for a continuous period of more than four months. The deficiencies below thes requirements are given in Table II. and are shown in the diagram, Fig. 2.

TABLE II.—Showing Deficiencies in Flow of Chagres River below 1,450, 1,900 and 2,350 cu. ft. per second from 1891 to 1902, inclusive.

Year.	Below 1,450 cu. ft.	Below 1,900 cu. ft.	Below 2,350 cu. ft.
1891	5,437,000,000	9,435,000,000	13,712,000,000
1892	1,069,200,000	2,575,000,000	6,505,200,000
1893	2,760,600,000	5,376,600,000	8,466,700,000
1894	3,164,200,000	6,631,600,000	11,095,700,000
1895	2,140,000,000	5,056,600,000	8,084,900,000
1896	2,708,000,000	5,685,700,000	8,873,800,000
1897	4,060,800,000	7,171,200,000	10,476,000,000
1898	1,555,000,000	3,382,000,000	6,363,000,000
1899	2,702,400,000	5,646,300,000	9,977,900,000
1900	4,523,000,000	8,217,000,000	12,494,000,000
1901	4,900,840,000	8,985,140,000	13,261,940,000
1902	505,400,000	2,005,000,000	5,326,600,000

To meet this deficiency it will be necessary to build a dam at or near Alhajuela. A dam built there, of the height proposed by the French engineers, would form a lake with a total storage capacity of 14,700,000 cu. ft. The greatest deficiency (13,712,000,000 cu. ft.) would require a storage of 660 cu. ft. per second for a period of eight months, making the total average requirements for these eight months 3,010 cu. ft. per second. The least discharge for eight months, of which there is any record, occurred in 1899 and averaged 4,340 cu. ft. per second, showing that there is ample margin for evaporation and contingencies

The last supposition provides for 14,600 passages yearly. Before this number of ships is reached it is probable that the average tonnage will be more than doubled and that this will represent a traffic of from 80,000,000 to 100,000,000 tons annually.

The system now proposed for the control of the Chagres and for the supply of water to the summit level is entirely automatic, except under two conditions which would very rarely occur. In case of extreme flood, if it is desired to pass any water through the canal, it must be done by opening the lock valves or the gates of a special by-pass. If the Alhajuela Dam is built to make an upper storage reservoir, gates must be opened by which the water will be received from that reservoir; or if flash-boards are used, those flash-boards must be replaced after floods of exceptional violence, an operation of the very simplest kind. The beauty of the plan recommended is that, in boldly treating the subject as a whole, the annoyance and dangers of detail are avoided.

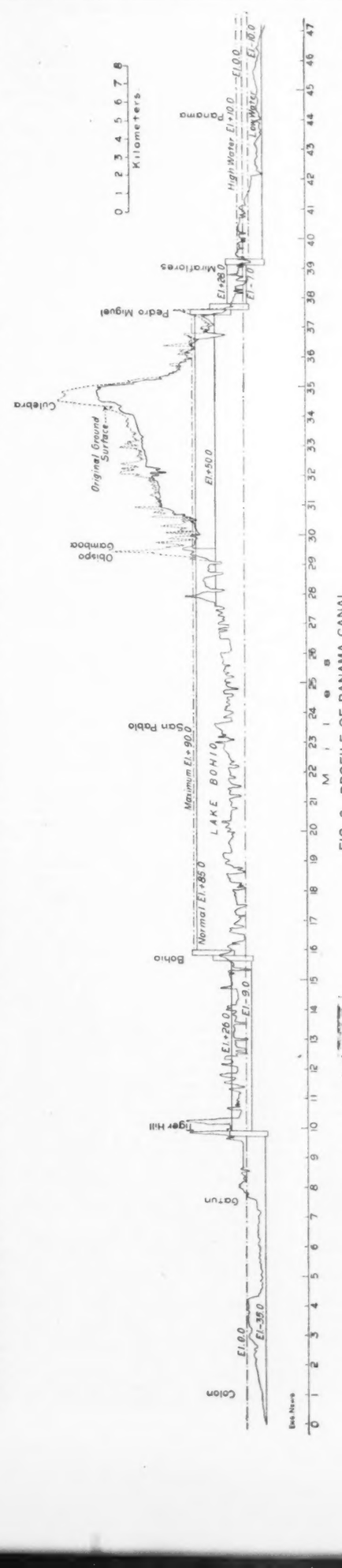

FIG. 2. PROFILE OF PANAMA CANAL.

CULEBRA CUT.

The term "Culebra Cut" is applied by the French company to the single mile of cutting of greatest magnitude. As used in this paper it is understood to apply to the entire cut between the Chagres Valley and the point where tide water is first reached on the Pacific side, the northern terminus of this cut being at Obispo and the southern terminus at Pedro Miguel, a total distance of nearly 8 miles, of which the southern 2 miles are in a comparatively low country. For 5 miles this cut is really through a mountain, the maximum original height, on the center line of the canal, being 330 ft. above mean tide. While in the upper part of the work where the cut was first opened there is some soft and slippery clay, nearly the whole of this excavation must be made through a material which has generally been rated at rock. It is, in fact, an indurated clay, not firm enough to class as shale, but perhaps quite as hard to work. It is intersected here and there by thin strata and dikes of hard limestone. It is a material which would weather rapidly and go to pieces in a northern climate where there is frost; in the damp, warm climate of the Isthmus it does better, but when fragments are immersed in water they fall into powder, and it would evidently be unsafe to expose the unprotected sides of this excavation to the wash of the water in the canal. It was the judgment of the Commission, in which the writer fully concurs, that this cut should be estimated on the basis of slopes of 1 on 1, which is a little flatter than the slope adopted by the new French company. This does not mean that the cut would be excavated to those lines. The plan selected by the French company, consisting of a number of benches connected by comparatively steep slopes, Fig. 3, is probably the best way to finish the sides of the cutting, but it was thought that an estimate based on uniform slopes of 1 on 1 would give aggregate results quite as close to the actual work as could be obtained by more complicated calculations; furthermore, it would probably leave a margin to cover such special repairs as may be found necessary where faults and weaknesses appear on the slopes. On the basis of 150 ft. bottom width and slopes of 1 on 1, this cut, 7.95 miles long between Obispo and Pedro Miguel, with the bottom at an elevation of 47 ft. above mean tide, was estimated by the Isthmian Canal Commission to contain 43,237,000 cu yds. With the depth remaining constant, each foot of increased or decreased width would represent, approximately, 150,000 cu. yds., provision being made for retaining the full width at a passing point, 1,600 ft. long, near the middle of this

section. As the side slopes are 1 on 1, the bottom width being constant, each foot that the bottom is raised or lowered would represent an approximate decrease or increase of 300,000 cu. yds., besides the bottom excavation above or below elevation 47. If the bottom were raised 3 ft., to elevation 50, it would save 1,000,000 cu. yds., reducing the volume to approximately 41,600,000 cu. yds. If the width of this cut were reduced from 150 to 100 ft., this would represent a further approximate saving of 7,500,000 cu. yds.

On the other hand, if the bottom of the canal were lowered to 35 ft. below mean tide, the bottom width being reduced to 100 ft., reverting to the original de Lesseps scheme for a tide-level canal, the amount of excavation in crossing the divide would be increased to about 85,000,000 cu. yds. While this quantity is enormous, it is not beyond the capacity of a well-conducted work.

The concentration of so large an amount of excavation in so small a distance is without precedent. The engineer will recognize at once that it requires thorough organization and tools specially adapted to the work. The large plant provided by the old French company is now from 15 to 20 years old. Those years have been years of unusual development in this class of machinery. Time is of the utmost importance. The wisest course would be to consign practically everything which is now on the Isthmus to the scrap heap, and handle this work with the best modern tools that can be obtained; some of these might be tools which could be bought in the market, but many must be specially designed for this particular work. Fortunately there is ample ground on which to deposit the spoil from this great cut both north and south of the divide, but the manner of conducting the work, both in general principles and in detail, should be thoroughly worked out before actual execution is begun. No work has ever been undertaken on which the highest class of practical engineering talent could produce so great economies as in this particular great concentrated excavation. The Isthmian Canal Commission estimated the cost of this excavation at 80 cts. per cu. yd.; bad management would quickly raise this to a dollar, and it is not impossible that with a carefully considered equipment the cost could be reduced to 60 cts. In this single cut $25,000,000 is an easy measure of the difference between competent and incompetent management.

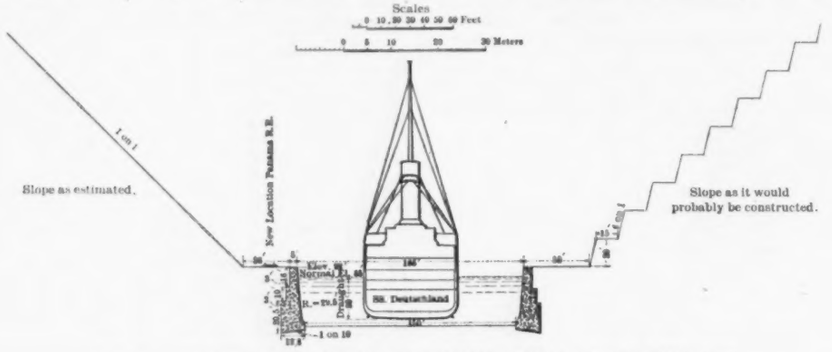

FIG. 3. TRANSVERSE SECTION OF PANAMA CANAL AT CULEBRA CUT.

As already stated, it is thought unsafe to allow the earth in this cut to be washed by the water of the canal. The French plans have recognized this and have provided for facing the slopes of the canal with masonry. The construction of this cut interferes with the old line of the Panama R. R. With the canal completed, the railroad will have little value except as a tender to the canal, and its most convenient location would be close to the canal. It is important to provide broad benches between the water of the canal and the slopes of the cut, so that any material which may break loose on the slopes can be stopped and handled before it reaches the water of the canal. It is desirable, if the sides of the canal are lined with masonry, to have this masonry nearly vertical, so that there would be no danger of a ship striking the masonry lining below water. These requirements are met by a special cross-section, which is shown in Fig. 3. The masonry walls may appear unnecessarily expensive, but their function is triple—they protect the slopes from the wash of the water; they accommodate the Panama R. R., and they provide a bench in case of accident on the slopes. These walls should be provided for a length of 32,000 ft.—about 6 miles. They would contain in the aggregate 1,200,000 cu. yds. of concrete masonry, and their length and cost is practically independent of the elevation of the canal bottom or the width of the canal.

Combining these two results and using the price of 80 cts. per cu. yd. for excavation and $8 per cu. yd. for concrete masonry, we have as an approximate estimate of the cost of this cut, with a bottom width of 150 ft. at elevation 50, $43,000,000. Each foot of increased width will represent an additional cost of $120,000, and each foot that the bottom may be lowered will represent an additional cost of about $400,000.

A tide-level canal 35 ft. deep, with a bottom width of 150 ft. between Obispo and Pedro Miguel, would cost nearly $90,000,000.

INTERMEDIATE LEVELS.

There would be two intermediate levels—a level 5.58 miles long between the Bohio and Tiger Hill locks on the Atlantic side, and a level 1.27 miles long between the Pedro Miguel and the Miraflores locks on the Pacific side. The former may be designated as the Tiger Hill Level and the latter as the Miraflores Level.

The normal surface of the water in the Tiger Hill Level is at elevation 26, the bottom of the excavation being at elevation — 9. This level involves nearly 8,000,000 cu. yds. of excavation, of which about one-third would be rock. Its estimated cost is about $5,000,000. For a portion of the distance the water in the canal is carried above the level of the surrounding country, and it is carried across the bed of the Chagres three times, twice at places where that bed is already abandoned, and once at Bohio, where the river will continue to flow until the discharge of the lake through the Gigante Spillway is accomplished. No complete borings have yet been taken along this line of the canal, but the indications are that no serious trouble is to be expected, the only possibility being leakage, which can be controlled by a moderate amount of puddling.

The normal surface of the water in the Miraflores Level is at elevation 28, the bottom of the excavation being at elevation — 7. This level is perfectly straight, and involves only 1,200,000 cu. yds. of excavation, of which one-quarter may be rock. The estimated cost is $800,000. This section is really the deepening of a natural valley, and the surface width of the water will exceed that of the canal proper. A small fixed dam, which will act as a spillway, will be required adjoining the Miraflores Lock.

MARITIME LEVELS.

The Atlantic Maritime Level will be 9.33 miles long, from the 6-fathom contour in Colon Harbor to the Tiger Hill lock, of which seven-tenths of a mile will be outside the terminus of the French canal. The difficulties of the 35-ft. channel are more marked here than at any other place. Colon Harbor practically lies entirely within the 6-fathom contour, so that the channel has to be extended from the terminus proposed for the French Canal completely through the harbor to deep water. It is probable that a considerable amount of coral rock will be met in excavating this line to deep water, although the exact amount is not known. The cost of the channel outside the terminus of the French Canal, excavated with a bottom width of 500 ft., was estimated by the Isthmian Canal Commission at $1,284,270. This work could be deferred until after the opening of the canal, but it must be done before the largest class of vessels can be accommodated. Very careful and full surveys must be made of this portion of the bay before the best location for this deep-water channel can be determined, and it is possible that it may be found best to cut through the artificial point on which the statute of Christopher Columbus now stands, making the terminus of the canal near the northern end of Colon, at which point some kind of protective breakwater may then be required. The 8.92 miles of canal proper, from the terminus of the French work, opposite the statue of Columbus, to the Tiger Hill lock, would involve an excavation of 14,761,639 cu. yds., this including an allowance for an inshore basin, and is estimated to cost $9,813,000, making the approximate cost of the entire maritime section $11,100,000, of which $1,300,000 can be deferred until after the opening of the canal.

The Pacific Maritime Section is 8.60 miles long from Miraflores lock to the 6-fathom contour in Panama Bay. Of this, 5.50 miles are canal proper, through a very low country, and the remaining 3.10 miles are open channel, through Panama Bay. This section involves the excavation of nearly 7,000,000 cu. yds., of which about one-fifth would be rock under water—the most expensive kind of excavation—and the remainder hydraulic dredging—the very cheapest kind of excavation. The estimated cost of this level is somewhat less than $8,000,000.

The description already given of the tide-level canal has included the line through to deep water in the Atlantic. On the Pacific side, the work between the Miraflores lock and the 6-fathom contour would be identical with that of the high-level canal. The Miraflores lock would be required as a tide lock. The Miraflores level would be lowered 28 ft. The excavation on this level would be, approximately, 2,500,000 cu. yds., at a cost of, approximately, $2,500,000, a portion being rock under water.

SPECIAL STRUCTURES.

If the tide-level canal were adopted, but two special structures would be required—a tide lock at Miraflores and a dam at Alhajuela, the object of the dam being simply to check the flow of extreme floods, and its construction could be deferred until the completion of the canal. The lock at Miraflores would be fitted with double gates and used strictly as a tide lock. In cases of extreme floods the gates should be kept closed at all times, so as to prevent any undue current through the summit cut. Under ordinary conditions it might be expedient to leave all the gates open when the tide is above mean stage, thus allowing a moderate current to flow from the Pacific to the Atlantic during high tide. The exact working of such a lock would, however, be determined by experience. The approximate cost of the lock and the Alhajuela Dam, including a railroad to the dam site, may be taken at $8,000,000.

On the high-level canal there would be six important constructions, besides five other works of less size. These 11 constructions are as follows: (1) Bohio Dam; (2) Gigante Spillway; (3) Bohio locks; (4) Pedro Miguel locks; (5) Tiger Hill lock; (6) Miraflores lock; (7) Obispo gates; (8) Tiger Hill spillway; (9) Miraflores spillway; (10) diversion channel near Gatun; (11) diversion of Panama Railroad.

BOHIO DAM.—The summit level is sustained by the Bohio Dam, although its height is regulated by the Gigante spillway. The situation of the dam, about three miles away from the spillway, is very important. The functions of the dam are confined to holding back the water, the dam never being exposed to any currents, either above or below, and the only source of danger being wave action and possible infiltration. The plan of dam which the writer prefers is described in the paper on "The Bohio Dam." Since that time his attention has been called to a form of metallic sheet piling, designed and used by Mr. George W. Jackson, of Chicago, composed of channels and I-beams, which seems to admit of penetration to very great depths, and may form an inexpensive and available method of absolutely closing the seepage through the valley, should such closure be considered sufficiently important. This arrangement of sheet piling is shown in Fig. 4.

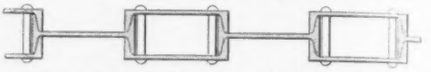

Fig. 4. Metallic Sheet Piling Designed by Geo. W. Jackson, Chicago, Ill.

GIGANTE SPILLWAY.—The Gigante spillway, although a work of considerable magnitude, involves no special difficulties in construction, as rock is found for its entire length above tide-water level. It would be built in the form of a masonry dam with a crest 2,000 ft. long. The estimated cost of this spillway is $1,200,000, this including the excavation for the foundation and such excavation as is necessary to make a clear approach for the water from the lake.

LOCKS.—There will be four sets of locks, of which two, at Tiger Hill and Miraflores, have a singe lift; and two, the Bohio and Pedro Miguel, a double lift. It is proposed to build twin locks in every case, so that an accident to a single lock would not close the canal to traffic. The construction of the second lock would, however, be properly deferred until after the opening of the canal. This arrangement requires 12 lock chambers, in all.

The plan of the French engineers involved 16 lock chambers, which they estimated to cost 137,000,000 francs, or 8,562,500 francs per chamber—in round numbers $1,700,000 per lock chamber.

The Isthmian Canal Commission, estimating on the line now recommended, made the cost of the locks $29,189,994, an average of $2,432,500 per lock chamber.

It is probable that a considerable saving could be made by using metal in combination with the concrete of the locks, but for present purposes, the estimate of the Isthmian Canal Commission may be accepted, and the cost of the locks given in round numbers as $29,000,000, of which about $17,000,000 would represent the cost of the first set of locks and $12,000,000 the cost of the second or twin locks.

OBISPO GATES.—Conditions can be conceived of in which it will be important to draw off the water from the Culebra Cut without disturbing the water in the lake. For this purpose a pair of gates should be placed at the north end of the cut. These gates, if made 100 ft. wide, with the necessary masonry and excavation, are estimated to cost $300,000.

TIGER HILL AND MIRAFLORES SPILLWAYS.—Two spillways are required, one adjoining the Tiger Hill lock and the other adjoining the Miraflores lock, to take care of excess water in the intermediate levels. These are small affairs, the estimated cost of the two being less than $100,000.

DIVERSION CHANNELS.—The principal diversion channel required will be that across the peninsula opposite Gatun; this would be a cut of considerable magnitude, and much of it would be through rock. It has been estimated of sufficient size to give a cross-section of 10,000 sq. ft. In addition to this the diversion channel dug along the east side of the canal by the old French company must be put in order to take the discharge of the Gatun and the various other local streams which would otherwise enter the canal. An allowance of $2,000,000 should be made for these works, nearly all of which will be for the Chagres diversion.

DIVERSION OF PANAMA RAILROAD.—Both tide-level and high-level canals interfere with the Panama Railroad, the latter much more than the former.

For the canal described in this paper, the location of the Panama Railroad will have to be changed for a short distance near Tiger Hill and for the entire distance between Bohio and Obispo, while from Obispo to Pedro Miguel the railroad would be carried through the cut made for the canal. The cost of these changes in the Panama Railroad is estimated at $1,300,000.

The tide-level canal interferes but little with the Panama Railroad; but, in order to avoid crossing the canal, a new line of railroad should be constructed from San Pablo to Obispo, about six miles, and the railroad should be carried through the cut between Obispo and Pedro Miguel; these changes would probably not cost more than $500,000.

ESTIMATES.

The estimates made in this paper are based on the report of the Isthmian Canal Commission, modified to suit changes in plans. In general, round figures have been taken, as it seems unwise to confuse the memory with a number of small figures, which measure less than the margin of error. By combining the figures already given in detail we have the approximate total cost of the two classes of canals.

To the figures so obtained, an addition has been made of 20% to cover the various incidental expenses and contingencies. The incidental expenses are understood to include engineering, policing and sanitation; in fact, all the expenses on the Isthmus which would not be borne by the contractors. They are not supposed to include any expenses of a home office or of interest during construction. This percentage is double that usually applied in estimating the cost of work in settled countries where risks are not unusual.

TIDE-LEVEL CANAL.—The cost of a canal on this plan would be approximately as given in Table III.

TABLE III.—Showing Estimated Cost of Tide-Level Canal.

Chagres section, Colon to Obispo	$90,000,000
Culebra section, Obispo to Pedro Miguel	90,000,000
Miraflores section	2,500,000
Pacific maritime section	8,000,000
Miraflores Lock	5,000,000
Alhajuela Dam and railroad	3,000,000
Diversion of Panama Railroad	500,000
	$199,000,000
Engineering and contingencies, 20%	39,800,000
Total	$238,800,000

Nearly the entire cost of this canal will be for excavation.

LOCK CANAL.—The estimated cost of a canal with locks, as described in this paper, the summit level varying from 85 to 90 ft., with three locks on each side, six in all, will be as given in Table IV.

TABLE IV.—Showing Estimated Cost of Lock Canal.

Atlantic maritime level, Colon to Tiger Hill	$11,100,000	
Tiger Hill level	6,000,000	
Lake Bohio	1,000,000	
Culebra Cut	43,000,000	
Miraflores level	800,000	
Pacific maritime level	8,000,000	
		$68,900,000
Bohio Dam	$2,000,000	
Gigante spillway	1,200,000	
Locks	29,000,000	
Obispo gates	300,000	
Tiger Hill and Miraflores spillways	100,000	
Diversion channels	2,000,000	
Diversion of Panama Railroad	1,300,000	
		35,900,000
		$104,800,000
Engineering and contingencies, 20%		20,960,000
Total		$125,760,000

The cost, therefore, of completing the Panama Canal on the lock plan would be about one-half that of completing it on the tide-level plan. This, however, does not tell the whole story. Neglecting the percentages for contingencies, all but $18,000,000 of the $199,000,000 estimated for the tide-level canal is for excavation. Of the $46,000,000 estimated as the cost of the Culebra Cut, in the high-level canal, $9,600,000 is for retaining walls along the sides of the cut; this reduces the cost of excavation to $59,000,000, or approximately three-fifths of the total cost of the canal (percentages still being omitted). In other words, although the cost of the tide-level canal is only about double that of the lock canal, the cost of excavation in the tide-level canal is about three times the cost of excavation in the lock canal. Excavation represents work which must be done entirely on the Isthmus. Much of the cost of special structures represents material which would be manufactured elsewhere. If it be assumed that one-half the cost of the special structures represents work on the Isthmus, it may be said, in a general way, that four-fifths of the cost of the lock canal and the whole cost of the tide-level canal will represent work on the Isthmus. As the tide-level canal will cost twice as much as the lock canal, the amounts to be expended on the Isthmus for the two canals will be approximately as five is to two. The number of workmen required on the Isthmus, as well as the time required to complete the work, will be determined by these conditions.

The tide-level canal will have to be completed before it can be opened to traffic, the only postponement being in a portion of the cost of the special structures, which is insignificant. The lock canal can be opened with the second set of locks unfinished, and before the channel in Colon Harbor is deepened. This will reduce the expenditures required before opening the canal to about $92,000,000, without the percentage, or to a total of $110,000,000.

These estimates are based on the conditions now existing at the Isthmus, advantage being taken of the work which has been done there by the French and of the Panama Railroad. The work done by the New Panama Canal Co. is practically all effective. Much of the work done by the old company is valueless. The canal which was excavated through the low country was taken out with a bottom width of 22 m. and a depth of 9 m., and the material was wasted close to the banks. To construct a canal of the increased dimensions now required will involve rehandling the spoil banks. Furthermore, the plan proposed in this paper would utilize the canal between Gatun and Bohio only as a channel for the Chagres, for which purpose it is of great value. The value of all this work, including the railroad, was estimated by the Isthmian Canal Commission at $40,000,000, which sum the New Panama Canal Co., of France, and the official liquidator, representing the shareholders and creditors of the defunct Universal Interoceanic Canal Co., have agreed to accept as the price for which they will deliver everything they now own on the Isthmus, together with their records, maps and other papers. If this is added to the foregoing estimates, the cost of the tide-level canal would be about $280,000,000 and that of the high-level canal $166,000,000, exclusive of interest during construction.

CONDUCT OF WORK.

The first thing to do is to clean up the Isthmus, to provide sewers where feasible, and sanitary rules everywhere, to furnish the entire line with good water, of which a great abundance may be had at moderate expense, and to compel the employees on the canal to drink nothing else. This will take at least a year.

The plans made by the New Panama Canal Co. were unusually complete for any preliminary work of this kind, but they were for a canal of different dimensions, with many details which would not be acceptable to American builders. The plans and examinations of the Isthmian Canal Commission were made for purposes of comparison and preliminary work rather than for actual construction. The final working designs remain to be made. Specifications must be prepared and all the necessary preliminaries which precede the letting of so great a work completed. Both the home and local organizations must be perfected. Much of this work can be done simultaneously with the sanitary preparations, and will take as long. A year spent in preparations, before the contracts are let, will save time in the end.

After the contracts are awarded, the contractors should be allowed another year to perfect their preparations. This is little enough time to provide for the organization of their forces and the purchase and collection of their machinery, much of which will have to be made after the contracts are awarded.

In two years after the transfer of the French property and the beginning of American occupation, actual construction work should fairly begin. The one greatest single piece of work is the Culebra Cut, and the time required to complete this cut will be the time which it will take to build the canal. All other work should be laid out with reference to this, so that, when it is completed, there will be no unfinished work to delay the opening of the canal.

The bulk of the laborers must be West Indian negroes, from Jamaica and perhaps some other islands. Skilled labor must come from the North, and generally be white. The methods of work should be so designed that the number of skilled workmen shall be as small as possible, and that they shall be protected from rain and sun when at work. It will probably be expedient to use electric power instead of steam as far as possible. A dam at the site of the Alhajuela Dam would furnish the power. If electric shovels could be used instead of steam shovels, but one skilled man, instead of two, would be required at each shovel, and the heat from the boiler would be avoided. The debilitating influence of the damp, warm climate remain, and a system of furloughs must be arranged which will permit the white employees to recuperate in northern climates at least once a year.

The French companies were private corporations, working with no greater powers than those derived from their concessions. All this will be changed when the work becomes a Government undertaking. The powers of the United States will be those of military occupation, under which a sanitary control and discipline can be exercised, which should remove the greatest difficulties which have hitherto beset the Isthmus of Panama.

DISCUSSION.

In presenting his paper Mr. Morison submitted several questions to the members for special discussion: (1) Is the high-level or the sea-level canal ultimately preferable? The author's view, stated in the paper, is that for the present at least the high-level canal is preferable, but he gave reasons for favoring the sea-level canal, looking aside from cost and time of construction. (2) Are three 28-ft. locks preferable to two 42-ft. locks, in descending from the summit level to the Atlantic? The author believes in a location north of Lake Bohio, slightly different from that which the Isthmian Canal Commission adopted (which is the route of the present French canal; the Commission's location requires two 42-ft. locks, and chiefly on the advantage which the author sees in three 28-ft. locks he prefers a slightly changed location. (3) What are the best means of ensuring the water supply to the summit level? The author's preference is for a postponement of any decision until after the canal is in operation, as no great trouble is likely to arise from this course and a good opportunity for study is had. (4) The tidal rise in Panama Bay is about 20 ft. A long channel must be dredged and excavated through this bay for the passage of ships. If the channel be constructed to give a depth of 35 ft. at mean stage, the depth at low water will be only 25 ft.; but a 35-ft. boat could enter during 18 hours out of the day, while a boat of 25 ft. draft could enter at all times. The saving of this plan over a channel 35 ft. deep at low water is considerable. Which depth is preferable?

The discussion was opened by the reading of a communication from Mr. M. Meigs. He inquired as to the amount of silt carried by the Chagres. He had had seven years' experience with a canal only 7 miles long, at Keokuk, and he found it required almost constant dredging. Due to special circumstances, 2 miles of his canal had not yet needed dredging, so that this work was all concentrated on a length of five miles. A river discharges into the canal, whence the rapid silting-up. The Chagres would discharge into the Panama canal directly in case of the sea-level plan, and all the silt it carries would be continually shoaling the canal. It seemed to him that the amount of dredging required to maintain a sea-level canal would be so much as to make this plan quite impossible. On the other hand, he considered the high-level canal an admirable solution of the problem. He considered the author's design of dam a good one, and the use of metal sheet-piling at its upper end a satisfactory means of rendering it watertight; a concrete sheet under the dam might be used in connection with this. The Bohio Lake, if built first, would offer an excellent and cheap way of transporting the spoil.

Mr. Theodore Paschke commended the author's plan as a bold and simple solution of the problem, which the French engineers had lacked courage to solve properly. He thought that the plan was somewhat incomplete in details, possibly intentionally. Thus, a receiving pool would be necessary below the Alhajuela dam to bring the moving water to rest. Referring to the proposed width of 400 ft. for the canal, he should prefer to go a little farther and widen it even more, so as to make it able to handle even the maximum possible flood without interruption of operation. He then dealt at some length with the question of the detritus brought down to the canal by the feeding streams, and proposed to reserve the lake from Alhajuela to Gamboa for the deposition of this material.

Prof. Wm. H. Burr attacked the author's change of location at the Atlantic side. He claimed that this was the old Lull route, and had been abandoned even by the old French company, whose location had been ratified by the new French company and recently by the Isthmian Canal Commission. The adoption of the Tiger Hill cut-off would render useless a part of the canal already excavated, and on this account alone should not be considered. The estimates of cost made by the author were so low that they seemed to have been made on a different basis from those of the Commission.

Mr. C. L. Harrison, showed that the minimum and even the normal velocity of flow in the canal were such that deposition of silt would occur; in case of minimum flow even quite fine material would be deposited. He considered that dredging on a large scale would prove necessary in the finished canal. He then discussed the matter of taking the Chagres into the canal at Obispo, in the case of the sea-level canal; extensive works would be required at this point, and their cost must be included in even a rough estimate. If the river could be diverted to either the Atlantic or the Pacific Ocean, by way of a separate diversion channel, a great difficulty would be overcome, but up to the present no suitable location for such a diversion has been found. On the whole, he considered that the difficulties involved in a sea-level plan are too great to make it advisable. The high-level canal, as a different problem, finds its complete solution in the Bohio-Gigante scheme. Mr. Harrison then explained some of the conditions at Panama, in the aim to explain the large allowance of 20% for engineering and contingencies. He outlined the requirements as to water supply and sanitation, and the policing of the isthmus, and concluded that the 20% allowance was small rather than large.

Mr. Boyd Ehle pointed out that the proposed Lake Bohio would cover most of the area furnishing detritus at pres-

ent. Above Alhajuela the character and extent of the country is such that but little detritus is carried by the river at this point. He expressed the opinion that no advantage of moment had been presented for the sea-level canal over the high level. In regard to the latter, he considered that the Tiger Hill cut-off was worthy of fuller study.

Mr. W. E. Crane inquired about the harbor channel at the Pacific end of the canal, whether the conditions were such that it would maintain itself or whether it would not rather require constant dredging to keep it open.

Mr. P. Bunau-Varilla, who was present, was able to answer this question, since he had, in 1884, put the first dredge to work on this channel. Six months after the channel was completed he had measured it, and found that the axis had maintained its depth exactly. He explained this from the shelter given by Panama Bay, such that there are no accretionary forces tending to silt up the channel. He then discussed the question of sea-level vs. high-level canal. The isthmus is of volcanic origin, as its rocks and their derived clays show. These materials are quite stable, and the waters of the Chagres are, in consequence, quite clear. On this account he had no fear on the score of sedimentation of appreciable amount. He was firmly convinced that the sea-level canal will ultimately be built; it is a perfect solution, and a canal to meet the highest requirements must be of this kind. Still, he thought it quite proper to construct the intermediate solution, the high-level canal, at present, as being sufficient for present requirements and giving a quicker result. But he felt that the transformation to a sea-level canal must come in time. This change can be carried on at any time and at any desired rate, without interrupting the operation of the canal.

In reply, Mr. Morison stated that his estimates were identical with those of the Commission as contained in the complete records, though these were not in the published report. The smaller figures of his estimate were due to a saving on the Bohio dam, a 3-ft. lesser depth in the lake, and the decreased depth of channel in Panama Bay. As to the sea-level canal, he said that of course the drop in the Chagres River must be allowed for, though he had not specifically mentioned this. Sedimentation in the canal would occur, he had no doubt, but modern dredging machinery is well adapted to work of this kind at very low cost. However, the sea-level canal, on account of its cost and the long time required for the work, should not and will not be built at present; the high-level canal is a satisfactory tool for the present and for a number of years to come.

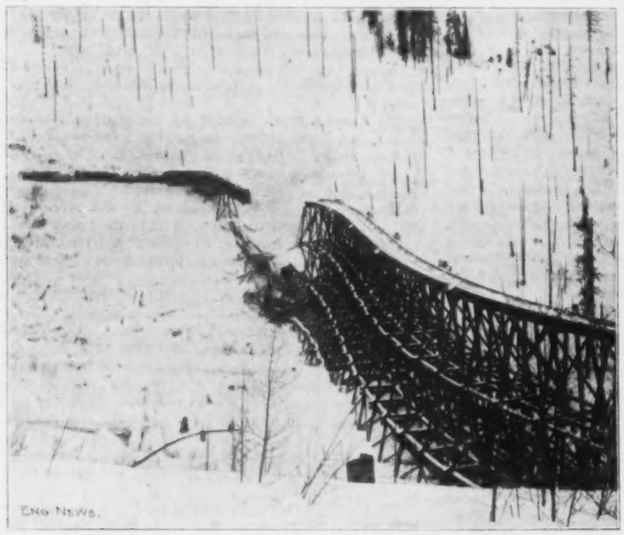

FIG. 1. VIEW OF S-BRIDGE ON THE NORTHERN PACIFIC RY., SHOWING BREAK AND TRAIN WRECK CAUSED BY A SNOWSLIDE ON FEB. 10, 1903.

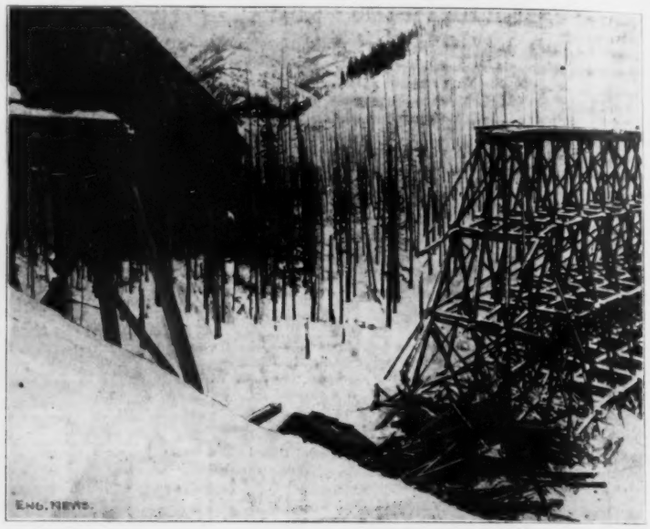

FIG. 2. NEAR VIEW OF THE BREAK AND WRECKAGE, S-BRIDGE, NORTHERN PACIFIC RY.

A REMARKABLE RAILWAY ACCIDENT.

The accompanying views show a remarkable railway structure and the no less remarkable train accident which resulted from its partial destruction by a snow slide on Feb. 10. The structure whose wreck is illustrated is the celebrated S-bridge, located on the Northern Pacific Ry., and crossing a small stream known as Willow Creek, near Mullan, Idaho. This "bridge" is a single track timber trestle some 300 ft. long and built on a reverse or ogee curve, the sinuous plan of the structure being necessitated by the loop which the railway makes at this point in its climb over the Bitter Root summit. At the time of the accident the snow in the bottom of the gorge buried the feet of the trestle bents some 30 ft. deep and had completely blocked the road ahead of a passenger train, which, with two extra locomotives and a broken down rotary snow-plow, was retreating from an attack of the snow-blocked road to the shelter of the nearest station in the rear.

The train consisted of a rotary snow plow with its pushing engine; the passenger engine followed by two passenger cars; a freight train caboose, and a helping engine at the rear end, and was standing with the rear engine, the caboose and the rearmost passenger car well over the trestle when the accident occurred. In the caboose were the crew of the rear engine and some others of the train crew, making eight persons in all, and in the rear passenger car there were some eight or nine persons. The accident was caused by a snow slide which started far up the mountain side and sweeping down the narrow gorge tore out the trestle structure for a short length directly under the standing train the caboose and rear locomotive of which plunged into the gap and were almost completely buried in the deep snow. The rear passenger car hung with one end over the gap and tipping down at a considerable angle, but was prevented from falling by the coupling to the car ahead. Of the passengers in the caboose one was rendered unconscious by the fall of that car, but soon recovered, and the others were practically uninjured. The deep bed of snow into which the car fell had cushioned the fall and preserved the lives of those who underwent the 80-ft. drop. The same agent also preserved the life of a frightened passenger in the car ahead who leaped from a window into the gorge below with no more serious consequence than a ducking in the soft snow. The other passengers in the rear car climbed into the car ahead with no injuries more serious than fright at their narrow escape.

The views which we show of the wreck have been furnished us by Mr. Arthur A. Booth, Mining Engineer, of Spokane, Wash. Fig. 1 shows a considerable length of the trestle with the break at the far end and the unwrecked portion of the train standing beyond. Fig. 2 is a near view of the break showing a portion of the wreckage and the passenger car partly overhanging the gap in the trestle floor.

NOTES FROM THE ENGINEERING SCHOOLS.

STEVENS INSTITUTE OF TECHNOLOGY.—Mr. Andrew Carnegie, vice-president of the Board of Trustees, has given $125,000 as an additional endowment for the Carnegie Laboratory of Engineering.

UNION UNIVERSITY, SCHOOL OF ELECTRICAL ENGINEERING.—Mr. Charles P. Steinmetz has been elected by the trustees to fill the new Chair of Electrical Engineering, and under his direction several assistants have been selected. Prof. Steinmetz, who was President of the American Institute of Electrical Engineers in 1901, is well known in the electrical world, particularly for his brilliant contributions to the theory of alternating current phenomena. He was born in Breslau, in the Prussian province of Silesia, in 1865, and graduated from the University of Breslau, coming to America in 1889; and since 1893 has been with the General Electric Co., first at Lynn, Mass., later at Schenectady, N. Y. The first two years of the course will be devoted to general culture studies, such as languages, literature, composition, logic, history, biology, etc.; the mathematics and mechanics being the only engineering subjects taught. The Junior year will be largely devoted to experimental and theoretical mechanics, and in part to electrical subjects. The Senior year will be entirely devoted to electricity.

A Post-Graduate Course in Electrical Engineering has also been established. This course is divided into two branches: (1) Electrical experimentation and original investigation; (2) evening lectures for the benefit of the hundreds of young engineers working at Schenectady. An electrical laboratory is being equipped, and will be supplemented by access to the works of the General Electric Co. and the American Locomotive Co.

UNIVERSITY OF ILLINOIS.—The College of Engineering of the University of Illinois will shortly ask the State Legislature for a considerable sum of money with which to increase the facilities for instruction. Under the able management of Prof. Ira O. Baker, the College has more than doubled its number of engineering students in the last three years, the number now being 600. This great and rapid growth necessitates more buildings and more laboratories.

DURING GERMAN ARMY MANOEUVERS last fall a wireless telegraph outfit was successfully used. The apparatus was carried by a wagon, current being generated by a dynamo driven by an oil motor. Continual communication was kept up between the general staffs, the cavalry divisions, and the chiefs of the army corps, over distances averaging 28 miles. The outfit was in charge of the balloon section.

THE MT. WASHINGTON RACK-RAILWAY was undertaken by its inventor, Sylvestor Marsh, as a cure for dyspepsia, according to a statement made by him in 1882 before a Senate investigating committee. In answer to the question: "How came you to build that railroad?" Mr. Marsh replied:

A.—Well, I built it for a pastime and to cure dyspepsia more than anything else. I retired from business in 1856. After living a few years doing nothing I had dyspepsia very badly and was compelled to do something to save my health. I got this idea and worked upon it and built different models of it until I worked it out. I was ridiculed a good deal and was laughed at, but it cured the dyspepsia.